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HOSKINS-WESTERN-SONDEREGGER INC LINCOLN NE
NATIONAL DAM SAFETY PROGRAM. NODAWAY LAKE DAM (MO 10178) LOWER --ETC(U)
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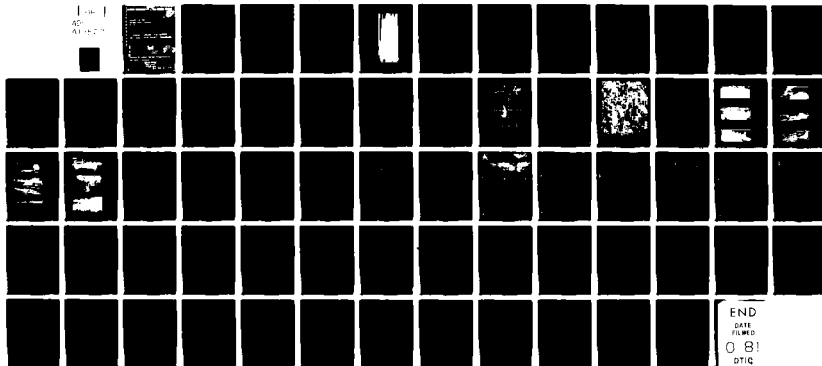
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PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

1983

FINAL REPORT

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REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
	AD-A105 272	
4. TITLE (and Subtitle) Phase I Dam Inspection Report National Dam Safety Program Nodaway Lake Dam (MO 10178) Nodaway County, Missouri		5. TYPE OF REPORT & PERIOD COVERED Final Report
7. AUTHOR(s) Hoskins-Western-Sonderegger, Inc.		6. PERFORMING ORG. REPORT NUMBER
9. PERFORMING ORGANIZATION NAME AND ADDRESS U.S. Army Engineer District, St. Louis Dam Inventory and Inspection Section, LMSED-PD 210 Tucker Blvd., North, St. Louis, Mo. 63101		8. CONTRACT OR GRANT NUMBER(s) DACW43-78-C-0155
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National Dam Safety Program. Nodaway Lake Dam (MO 10178) Lower Mississippi - 102 River Basin, Nodaway County, Missouri. Phase I Inspection Report.		
18. SUPPLEMENTARY NOTES		
19. KEY WORDS (Continue on reverse side if necessary and identify by block number) Dam Safety, Lake, Dam Inspection, Private Dams		
20. ABSTRACT (Continue on reverse side if necessary and identify by block number) This report was prepared under the National Program of Inspection of Non-Federal Dams. This report assesses the general condition of the dam with respect to safety, based on available data and on visual inspection, to determine if the dam poses hazards to human life or property.		

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PHASE I REPORT
NATIONAL DAM SAFETY PROGRAM

Name of Dam Nodaway Lake Dam
State Located Missouri
County Located Nodaway County
Stream Tributary to Canal Branch One Hundred and Two River
Date of Inspection July 12, 1978


Nodaway Lake Dam was inspected by an interdisciplinary team of engineers from Hoskins-Western-Sonderegger, Inc. The purpose of the inspection was to make an assessment of the general condition of the dam with respect to safety, based upon available data and visual inspection, in order to determine if the dam poses hazards to human life or property.

The guidelines used in the assessment were furnished by the Department of the Army, Office of the Chief of Engineers and developed with the help of several Federal and State agencies, professional engineering organizations, and private engineers. Based on these guidelines, this dam is classified as an intermediate size dam with a high downstream hazard potential. Failure would threaten the life and property at four farmsteads located within the first two miles downstream of the dam and would also cause appreciable damage to four improved road crossings. The estimated damage zone extends eight miles downstream of the dam.

Our inspection and evaluation indicates that the spillway does not meet the criteria set forth in the guidelines for a dam having the above size and hazard potential. The spillway will pass 0.48 of the Probable Maximum Flood without overtopping the dam. An additional deficiency, in accordance with the guidelines, is the lack of seepage analysis. These analyses should be obtained in the future.

Other deficiencies visually observed by the inspection team were small trees growing on the upstream embankment slope, some deterioration of the limestone riprap, and dense growth of trees and brush in the channel downstream from the principal spillway.

Several items of preventive maintenance need to be initiated by the owner. These are described in detail in the body of the report. Copies of the report have been furnished the dam owner and the Governor of Missouri.


Harold P. Hoskins, P.E.
Hoskins-Western-Sonderegger, Inc.
Lincoln, Nebraska

SUBMITTED BY **SIGNED**
Chief, Engineering Division

APPROVED BY **SIGNED**
Colonel, CE, District Engineer

1 SEP 1978

Date

1 SEP 1978

Date



PHOTO NO. 1
OVERVIEW OF LAKE AND DAM
TAKEN FROM ENTRANCE TO
PARKING AREA LOOKING SOUTHWEST.
DAM IS LOCATED AT LEFT
CENTER OF PHOTOGRAPH

Accession For	
NTIS GRA&I	<input checked="" type="checkbox"/>
DTIC TAB	<input type="checkbox"/>
Unannounced	<input type="checkbox"/>
Justification	
By	
Distribution/	
Availability Codes	
Aircraft and/or	
Dist	Special
R 1231	

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM
NODAWAY LAKE DAM - ID NO. MO 10178

TABLE OF CONTENTS

<u>Paragraph No.</u>	<u>Title</u>	<u>Page No.</u>
SECTION 1 - PROJECT INFORMATION		
1.1	General	1
1.2	Description of Project	1
1.3	Pertinent Data	2
SECTION 2 - ENGINEERING DATA		
2.1	Design	5
2.2	Construction	5
2.3	Operation	5
2.4	Evaluation	5
SECTION 3 - VISUAL INSPECTION		
3.1	Findings	6
3.2	Evaluation	7
SECTION 4 - OPERATIONAL PROCEDURES		
4.1	Procedures	8
4.2	Maintenance of Dam	8
4.3	Maintenance of Operating Facilities	8
4.4	Description of Any Warning System in Effect	8
4.5	Evaluation	8
SECTION 5 - HYDRAULIC/HYDROLOGIC		
5.1	Evaluation of Features	9
SECTION 6 - STRUCTURAL STABILITY		
6.1	Evaluation of Structural Stability	11
SECTION 7 - ASSESSMENT/REMEDIAL MEASURES		
7.1	Dam Assessment	12
7.2	Remedial Measures	12

APPENDIX A - MAPS

Plate 1	Vicinity Topography
Plate 2	Location Map
Plate 3	Orthophotograph

APPENDIX B - PHOTOGRAPHS

Photographs of Dam and Lake (No. 2 through No. 13)

APPENDIX C - PLANS AND REPORTS

Sheet 4 of 22 (SCS)	Plan of Structure
Sheet 6 of 22 (SCS)	Principal Spillway Plan and Profile
Sheet 7 of 22 (SCS)	Foundation Drain System
Sheet 2 of 3 (SCS)	Geologic Investigations
	Soil Mechanics/Soil Engineering Report
Sheet 3 of 3 (SCS)	Cross Sections

APPENDIX D - HYDROLOGIC COMPUTATIONS

Plate D1	Inflow Hydrographs
Sheet 2 of 4 (SCS)	Flood Routing

SECTION 1 - PROJECT INFORMATION

1.1 GENERAL

a. Authority. The National Dam Inspection Act, Public Law 92-367, authorized the Secretary of the Army, through the Corps of Engineers, to initiate a program of safety inspection of dams throughout the United States. Pursuant to the above, the St. Louis District, Corps of Engineers, District Engineer directed that a safety inspection of the Nodaway Lake Dam be made.

b. Purpose of Inspection. The purpose of the inspection was to make an assessment of the general condition of the dam with respect to safety, based upon available data and visual inspection, in order to determine if the dam poses hazards to human life or property.

c. Evaluation Criteria. Criteria used to evaluate the dam were furnished by the Department of the Army, Office of the Chief of Engineers, in "Recommended Guidelines for Safety Inspection of Dams". These guidelines were developed with the help of several Federal agencies and many State agencies, professional engineering organizations, and private engineers.

1.2 DESCRIPTION OF PROJECT

a. Description of Dam and Appurtenances.

(1) Nodaway Lake Dam is an earth fill approximately 1480 feet in length with maximum height of about 57 feet. Topography adjacent to the dam is gently rolling. Soils on the lower slopes are apparently derived from fine grained glacial till. Upland soils appear to be loessial in origin.

(2) The primary or principal spillway consists of a reinforced concrete riser with a 30 inch diameter reinforced concrete pipe conduit outlet.

(3) The emergency spillway is cut into glacial till on the left (east) abutment. It has a bottom width of 40 feet and side slopes of 3H on 1V.

b. Location. The dam is located in the north central portion of Nodaway County, Missouri, as shown on Plate 2. The lake formed by the dam is shown on Plate 1 in the NE 1/4 of Section 20, T65N, R35W and the SE 1/4 of Section 17, T65N, R35W. The lake is also shown on the Maryville NE Orthophotograph (Plate 3).

c. Size Classification. Criteria for determining the size classification of dams and impoundments are presented in the guidelines referenced in paragraph 1.1c above. Based on these criteria, this dam and impoundment is in the intermediate size category.

d. Hazard Classification. Guidelines for determining hazard classification are presented in the same guidelines as referenced in paragraph c above. Based on referenced guidelines, this dam is in the High Hazard Classification. The estimated damage zone extends eight miles downstream of the dam. Within the first two miles downstream of the dam are four farmhouses with associated farm buildings and four improved road crossings.

e. Ownership. The dam is owned by the Missouri Department of Conservation.

f. Purpose of Dam. The dam forms a 70 ± acre recreational lake and provides flood retardation for the 100-year frequency rainfall event.

g. Design and Construction History. The dam was constructed in 1966. The design and the plans for construction were prepared by the Soil Conservation Service (SCS), Columbia, Missouri. Portions of these plans are included with this report as Appendix C.

h. Normal Operating Procedure. Normal rainfall, runoff, transpiration and evaporation all combine to maintain a relatively stable water surface elevation. Information was not available relative to flow through the emergency spillway.

1.3 PERTINENT DATA

a. Drainage Area - 730 acres.

b. Discharge at Damsite.

(1) All discharge at the damsite is through an uncontrolled reinforced concrete drop inlet pipe principal spillway and a grassed earth channel ungated emergency spillway.

(2) Estimated maximum flood at damsite - unknown.

(3) The principal spillway capacity varies from 0 c.f.s. at elevation (1083.0) to 129 c.f.s. at the crest of the emergency spillway (1086.0).

(4) The principal spillway capacity at maximum pool elevation (1087.3) is 131 c.f.s. Maximum pool elevation is that design value for freeboard pool level as furnished on SCS as-built plans.

(5) The emergency spillway capacity at maximum pool elevation is 141 c.f.s.

(6) The total spillway capacity at maximum pool elevation is 272 c.f.s.

c. Elevation (Feet Above M.S.L.).

(1) Top of dam - 1089.0 (SCS plans) - 1089.3 (survey 12 July 1978).

(2) Principal spillway crest - 1083.

(3) Emergency spillway crest - 1086.

(4) Streambed at centerline of dam - 1037±.

(5) Maximum tailwater - unknown.

d. Reservoir. Length of maximum pool - 3700 feet ±.

e. Storage (Acre-feet). Top of dam - 2140.

f. Reservoir Surface (Acres).

(1) Top of dam - 80 acres ±.

(2) Spillway crest - 70 acres ±.

g. Dam.

(1) Type - earth embankment.

(2) Length - 1480 feet ±.

(3) Height - 57 feet ± maximum, 52± at centerline.

(4) Top width - 18 feet.

(5) Side Slopes -

(a) Downstream - 2.5H on 1V down to a 15 foot wide berm and 4H on 1V below the berm.

(b) Upstream - 3H on 1V with 10 foot and 30 foot wide berms.

(6) Zoning - none shown on plans.

(7) Impervious core - none shown on plans but all embankment material reported to be clay (CL) as shown in Appendix C.

(8) Cutoff - Plans show cutoff varying in depth from 5 to 15 feet with 10 foot bottom width and side slopes of 1H on 1V.

(9) Grout Curtain - none.

(10) Drains - Plans show foundation drain approximately 5 feet in depth extending from about station 6+30 to station 11+10 (stationing according to plans).

h. Diversion and Regulating Tunnel. None.

i. Spillway.

(1) Principal.

(a) Type - standard SCS reinforced concrete with drop inlet and a 30 inch reinforced concrete pressure pipe.

(b) Length of weir - 19 feet.

(c) Crest elevation - 1083.0 feet m.s.l.

(2) Emergency.

(a) Type - standard SCS grassed earth channel.

(b) Control section - 40 foot bottom width 3:1 side slopes.

(c) Crest elevation - 1086.0 feet m.s.l.

(d) Upstream channel - clear and well grassed.

(e) Downstream channel - badly blocked with trees and brush which could affect tailwater conditions on principal spillway discharge.

j. Regulating Outlets.

(1) Principal spillway.

(a) 24" diameter gated port (elevation 1075.0 invert).

(b) 16" diameter ASA Class 125 valve (elevation 1053.56) from as-built plans.

(2) Emergency spillway - None.

SECTION 2 - ENGINEERING DATA

2.1 DESIGN

Data on the geologic investigation, hydraulic/hydrologic computations, construction plans, and the soil mechanics/soil engineering report were supplied by the Soil Conservation Service, Columbia, Missouri. This information is shown in Appendix C and Appendix D.

2.2 CONSTRUCTION

No construction data were readily available; however, it is reported that the dam was constructed with SCS engineering supervision and standard inspection and quality control procedures.

2.3 OPERATION

No information was available on the maximum loading on the dam.

All spillways are uncontrolled.

No information available on operation of discharge system.

2.4 EVALUATION

a. Availability. The engineering data shown in Appendix C was readily available from the SCS, Columbia, Missouri.

b. Adequacy. The available data and reported information are adequate to assess the design and stability of the structure.

c. Validity. The available data and analyses conform with accepted practice.

SECTION 3 - VISUAL INSPECTION

3.1 FINDINGS

a. General. A visual inspection of Nodaway Lake Dam was made on July 12, 1978. Personnel making the inspection are employees of Hoskins-Western-Sonderegger, Inc., Lincoln, Nebraska, and included Garold Ulmer, civil engineer; Richard Walker, Hydrology, and Rey S. Decker, Soil Mechanics and Geology.

Results of the visual inspection are summarized below. Photographs are shown in Appendix B.

b. Dam. Rough measurements of the profile along the crest of the dam and emergency spillway centerline and cross-sections of the embankment and spillway indicate that the dam was constructed according to the plans shown in Appendix C.

The dam is covered with an excellent growth of adapted grasses and legumes.

A few small trees were observed along the upstream face. Riprap on the upstream slope extended 3 to 4 feet above the water surface. The riprap consists of a rather poor grade of thin bedded limestone and some deterioration was noted. No significant erosion was noted on the upstream slope.

Surface materials in the dam consist of lean to fat clays (CL or CH).

There was no indication of emergence of the phreatic line or other seepage on the downstream slope or along the toe of the dam.

The foundation drain was discharging clear effluent at the rate of approximately 1 gal/min. A few small seeps were observed around the left (looking downstream) side of the principal spillway stilling basin or plunge pool. These seeps extended up the plunge pool slopes about 3 feet above the water surface and emerged through CL material. The very small discharge from these seeps was clear.

No cracks, slides, or abnormal deformations were observed in the embankment.

c. Appurtenant Structures.

(1) Principal Spillway - There were no indications of spalling or deterioration of the principal spillway riser nor the concrete pipe outlet. The lake level was at the spillway crest elevation at the time of the inspection.

(2) Emergency Spillway - The emergency spillway is well vegetated with adapted grasses. It looked very good with no evidence of erosion in the bottom or side slopes.

(3) Drawdown Facility - The plans show a 30 inch R/C pipe entering the base of the principal spillway riser. Flow through this system is controlled by a 16 inch valve at the base of the riser and a 24 inch slide headgate near the top of the riser (see sheet 6 of 22 of the plans). This system is designed as a drawdown facility to evacuate the reservoir. It is not known whether or not the gates and valves are operable.

d. Reservoir Area. No wave wash, excessive erosion or slides were observed along the shore of the reservoir. The east shoreline was riprapped for a distance of 1200 to 1300 feet upstream from the dam.

e. Downstream Channel. The channel downstream from the principal spillway is badly clogged with trees and brush.

f. Other. There is an old gully plug or small farm pond about 150 feet downstream from the toe of the dam opposite about centerline station 4+50 (stationing as shown on the plans). The pond was dry at the time of the inspection.

3.2 EVALUATION

None of the conditions observed indicate a need for immediate remedial action. Trees on the upstream slope of the dam, trees and brush in the downstream channel, and slight deterioration of the riprap are deficiencies which could ultimately impair the integrity of the dam if left uncontrolled or uncorrected.

SECTION 4 - OPERATIONAL PROCEDURES

4.1 PROCEDURES

The pool level is normally controlled by rainfall, runoff, evaporation and capacity of the uncontrolled spillways. Procedures for operating the drawdown facility are not known.

4.2 MAINTENANCE OF DAM

The dam is reasonably well maintained. Action should be taken to correct the minor deficiencies noted in Sections 3 and 7.2.

4.3 MAINTENANCE OF OPERATING FACILITIES

It is not known if the drawdown facility is operable nor if and when the system has been operated.

4.4 DESCRIPTION OF WARNING SYSTEM IN EFFECT

The inspection team is not aware of any existing warning system for this dam.

4.5 EVALUATION

The dam and appurtenances appear to be well maintained with the exception of some laxity in controlling tree growth on the upstream face and allowing a few sections of the riprap wave protection to deteriorate.

SECTION 5 - HYDRAULIC/HYDROLOGIC

5.1 EVALUATION OF FEATURES

a. Design Data. Pertinent hydraulic and hydrologic data which were taken from as-built plans furnished by the SCS are tabulated in Appendix D on Hydrologic Computations. The supporting computations are attached.

b. Experience. The drainage area and lake surface area are developed from USGS Maryville Quadrangle and orthophoto sheets. The spillway and dam layout are from as-built plans and surveys made during inspection. There were no major discrepancies discovered as far as the hydraulic structural components of the dam and spillway were concerned.

c. Visual Observations.

(1) Principal and emergency spillways are in good condition except as noted.

(2) The emergency spillway does not appear to have ever been used.

(3) The emergency spillway and exit channel are in the left hillside abutment away from the dam. Spillway releases will not endanger the integrity of the dam.

d. Overtopping Potential. The spillways are too small to pass the probable maximum flood without overtopping. One-half the PMF will overtop the dam by 0.24' for a period of 3.0 hours. The spillways will pass the 0.48 PMF without overtopping. The existing spillways will pass the 100-year frequency flood without overtopping. The results of the routings through the dam are tabulated in regards to the following conditions.

Frequency	Inflow Discharge c.f.s.	Outflow Discharge c.f.s.	Maximum Pool Elevation	Freeboard Top of Dam Min. Elev. 1089.3	Time Dam Overtopping Hr.
100 Yr.	2239*	131*	1085.95*	+3.35	0
1/2 PMF	3380	1014	1089.54	-0.24	3.00
PMF	6802	6190	1091.11	-1.80	4.25
0.48 PMF	3000	800	1089.3	0	0

*Data taken from SCS as-built plans

According to the recommended guidelines from the Department of the Army, Office of the Chief of Engineers, this dam is classified as having a high hazard rating and an intermediate size. Therefore, the PMF is the test for the adequacy of the dam and its spillways.

The St. Louis District, Corps of Engineers, in a letter dated 13 July, 1978 has estimated the damage zone as extending eight miles downstream from the dam. Within the first two miles downstream are four farmhouses with associated farm buildings and four improved road crossings. This fact was verified by field inspection.

SECTION 6 - STRUCTURAL STABILITY

6.1 EVALUATION OF STRUCTURAL STABILITY

a. Visual Observations. Maintenance features that could affect the long time safety of the dam are discussed in Section 3.2.

Hydraulic/Hydrologic analyses presented in Section 5 indicate that the dam will be overtopped by the probable maximum flood. Under those conditions, water would flow over the top of the dam to a depth of 1.8 feet \pm for about 4.25 hours.

b. Design and Construction Data. The engineering data, analyses, and plans supplied by the SCS conform with accepted practice and are considered adequate to assess the structural stability of the dam.

There is no reason to question the adequacy of construction supervision and quality control.

c. Operating Records. There are no appurtenant structures that require operational functions.

d. Post Construction Changes. The inspection party is not aware of any post construction changes.

e. Seismic Stability. This dam is located in the Zone 1 seismic probability classification area. An earthquake of this magnitude is not expected to cause structural failure of this dam.

SECTION 7 - ASSESSMENT/REMEDIAL MEASURES

7.1 DAM ASSESSMENT

a. Safety. The few deficiencies in maintenance that were observed, a few small trees and minor deterioration of the riprap on the upstream slope, should be corrected and/or controlled. The probable maximum flood (PMF) will overtop the dam, however, the spillways are adequate to pass the flood resulting from the 0.48 PMF without overtopping. The dam is designed to impound the flood resulting from the storm that has a 1 percent (1 in 100 years) chance of occurrence without flow in the emergency spillway.

b. Adequacy of Information. The information presented in this report is considered adequate to assess the safety of the structure. Seepage analyses were not found, which is a deficiency that should be corrected in the future.

c. Urgency. There is no immediate urgency to accomplish the remedial measures discussed in paragraph 7.2.

d. Necessity for Phase II. Based on the results of the Phase I inspection, Phase II investigations are not considered necessary.

e. Seismic Stability. The dam is located in Seismic Zone 1. An earthquake of this magnitude is not expected to be hazardous to this dam.

7.2 REMEDIAL MEASURES

a. Alternatives. The size of the spillway could be enlarged to pass the probable maximum flood.

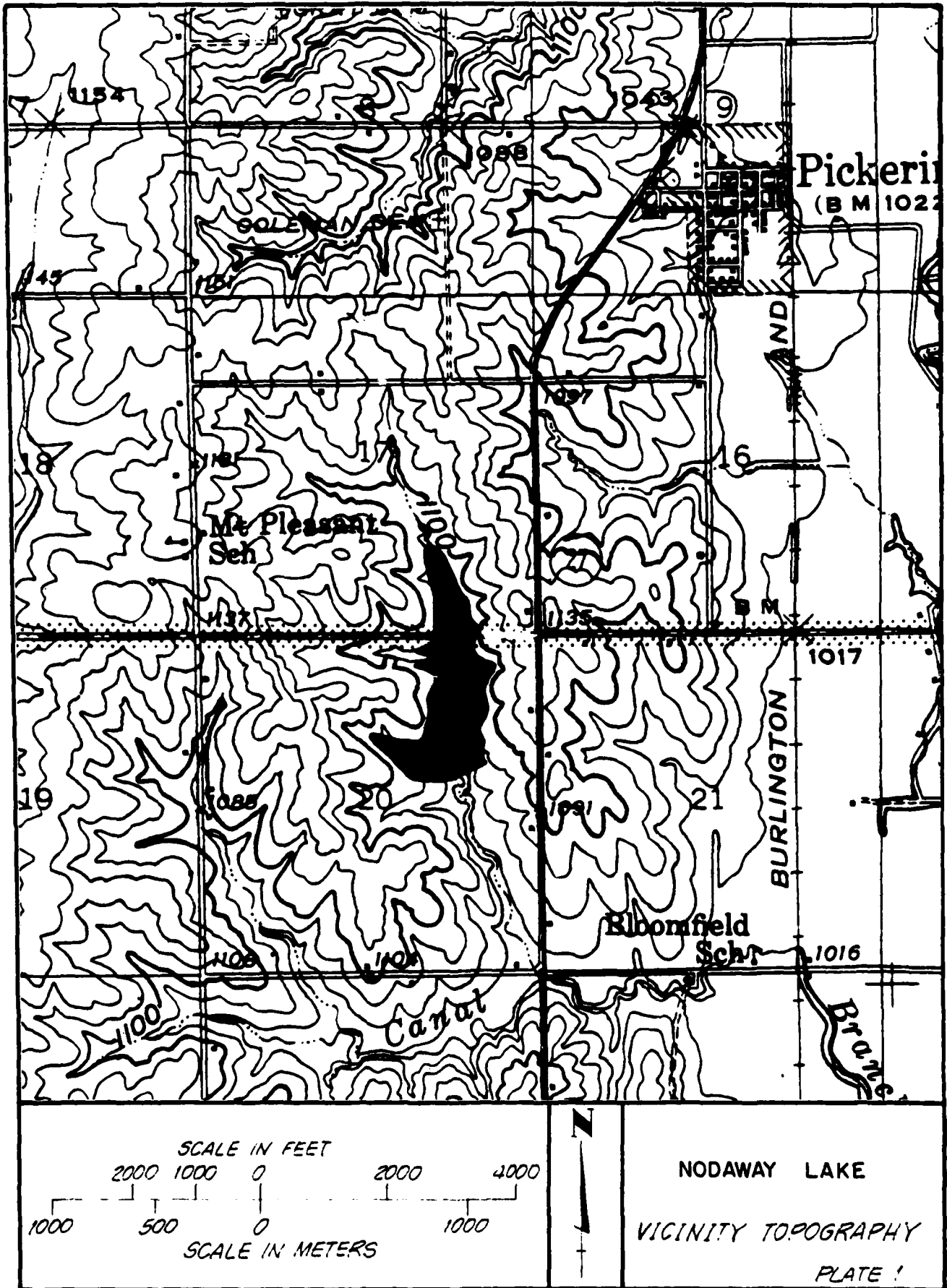
b. O&M Maintenance and Procedures.

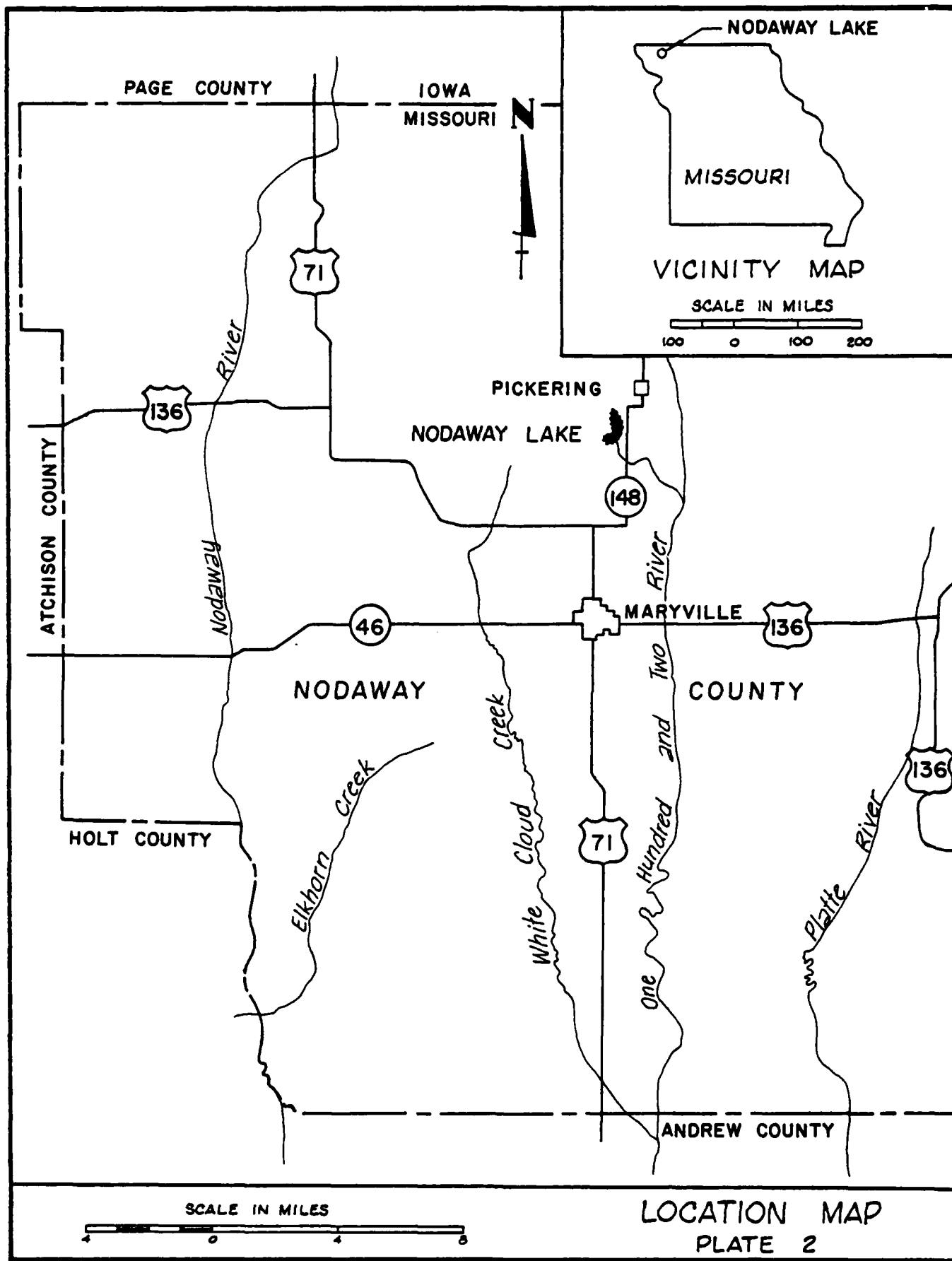
(1) The trees should be removed from the upstream face of the dam and measures initiated to prevent recurrence.

(2) Additional riprap should be installed in those areas of the upstream face where wave erosion is evident.

(3) The affects of the tree clogged channel downstream from the principal spillway upon tailwater elevations in the plunge pool are not known. The downstream channel should be cleared of trees and brush and measures initiated to prevent recurrence of growth.

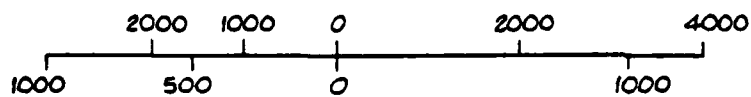
APPENDIX A
MAPS







SCALE IN FEET



SCALE IN METERS



NODAWAY LAKE
ORTHOPHOTOGRAPH
PLATE 3

APPENDIX B
PHOTOGRAPHS



PHOTO NO. 2
LOOKING UPSTREAM
IN EMERGENCY
SPILLWAY



PHOTO NO. 3
LOOKING INTO
FOREBAY OF
EMERGENCY
SPILLWAY



PHOTO NO. 4
LOOKING WEST
ACROSS LAKE
AND UPSTREAM
FACE OF DAM



PHOTO NO. 5
UPSTREAM SLOPE
FROM ABOUT
STA. 4+00 TO EAST

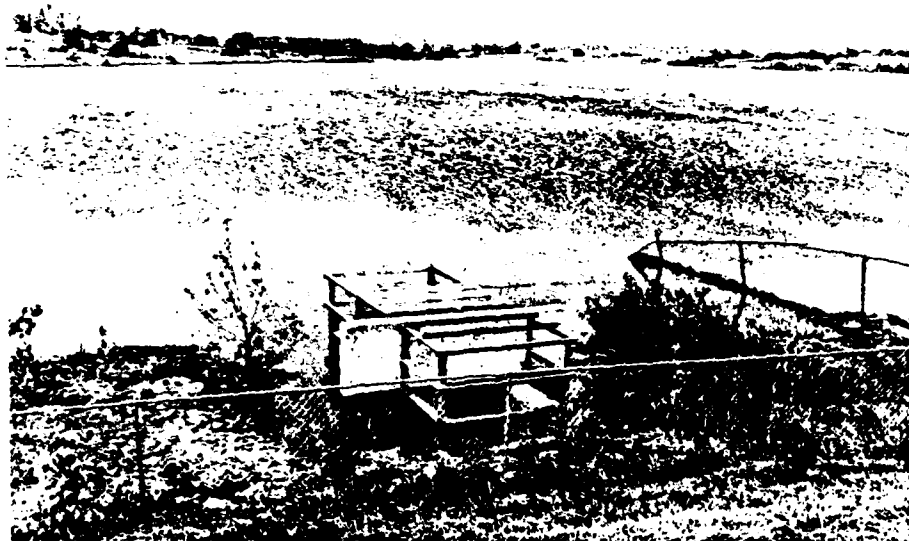


PHOTO NO. 6
PRINCIPAL SPILLWAY
FROM ABOUT
STA. 7+60



PHOTO NO. 7
LOOKING EAST
FROM WEST END
OF DAM



PHOTO NO. 8
LOOKING NORTH
ACROSS RESERVOIR
FROM WEST END
OF DAM



PHOTO NO. 9
LOOKING AT
DOWNSTREAM CHANNEL
FROM TOP OF DAM



PHOTO NO. 10
DOWNSTREAM SLOPE
FROM STA. 3+00
TO EAST



PHOTO NO. 11
LOOKING UPSTREAM
INTO STILLING
BASIN



PHOTO NO. 12
SEEP AREA ON
LEFT SIDE OF
STILLING BASIN

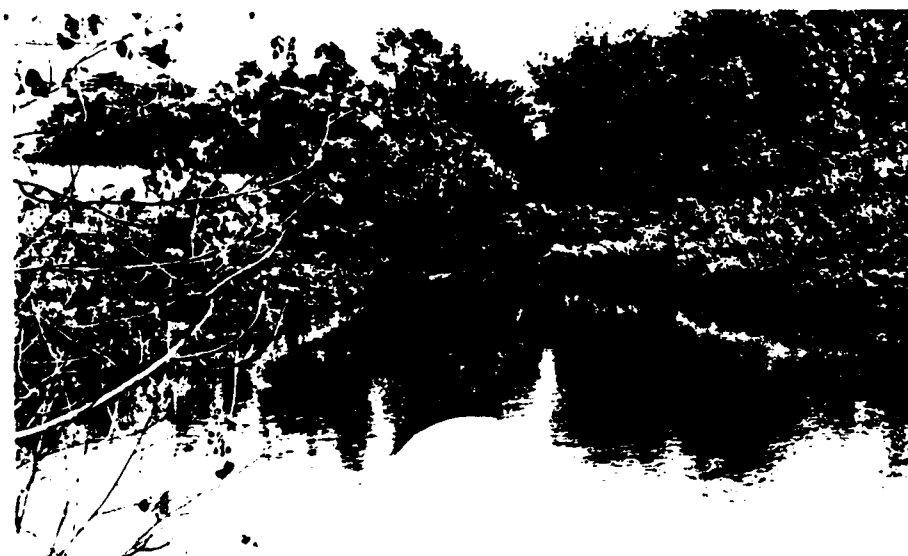
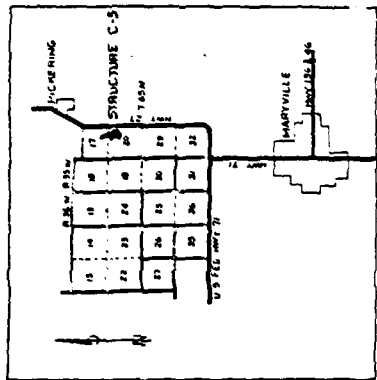
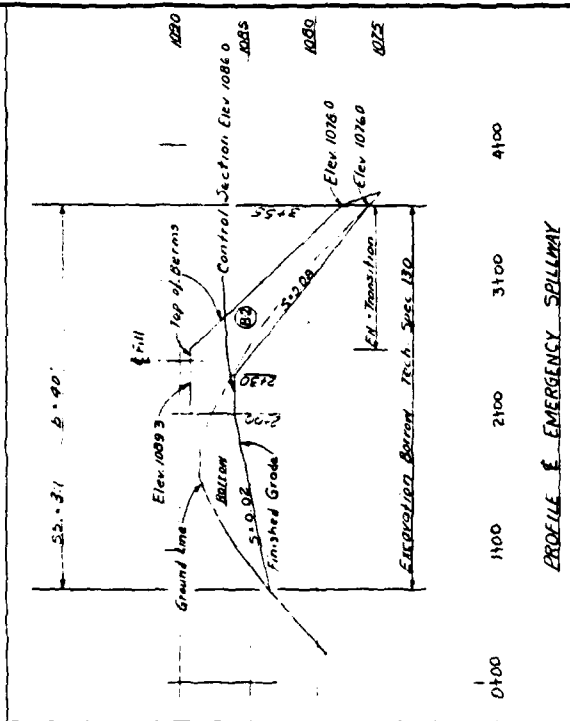


PHOTO NO. 13
LOOKING DOWN
CHANNEL FROM
STILLING BASIN

APPENDIX C
PLANS AND REPORTS



VICINITY MAP

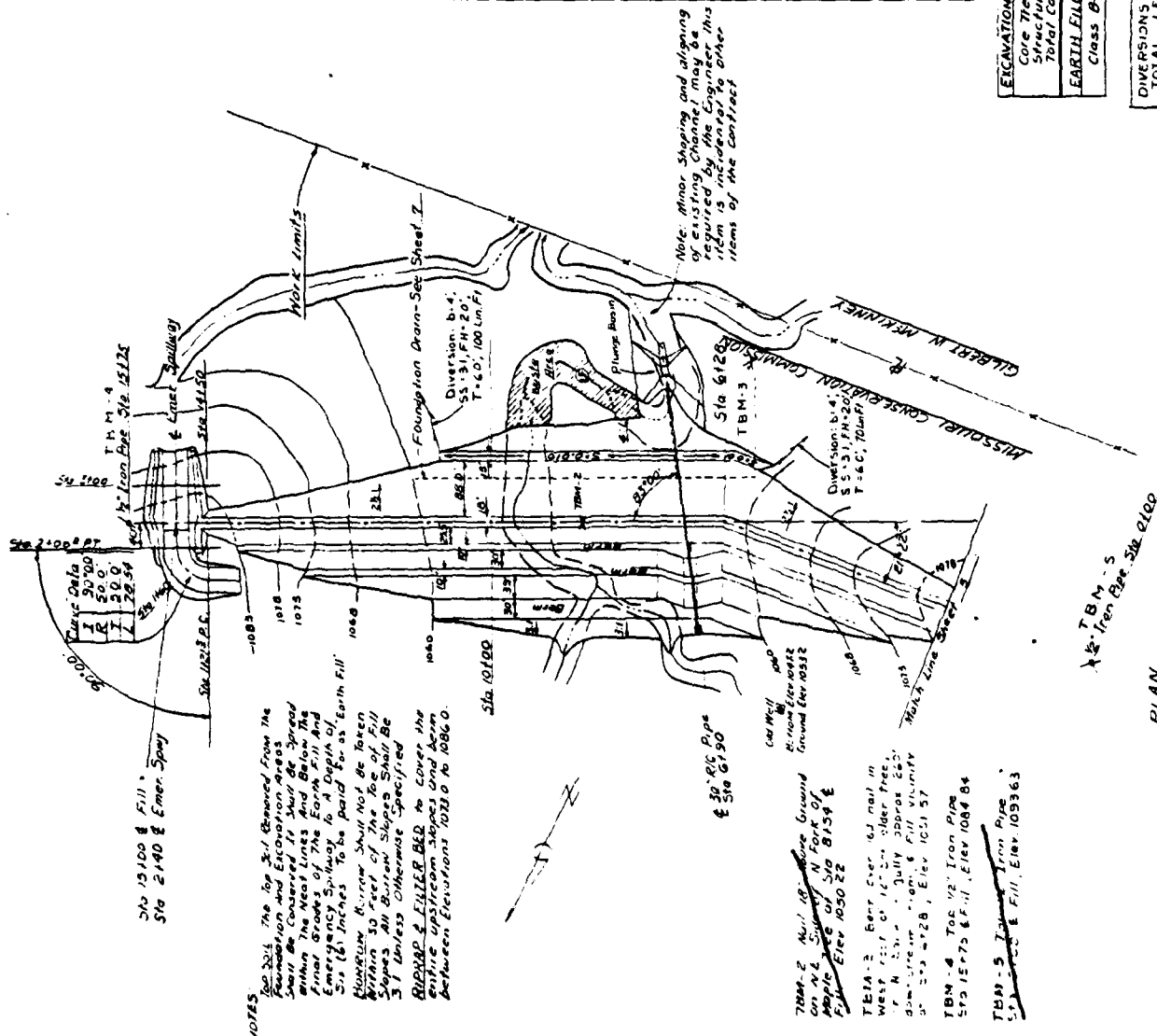


PROFILE & EMERGENCY SPILLWAY

ELEVATION - COMMON TECH SPEC 180	
Core Trench	5137.0000 C.W.S.
Structure	5142.0000 C.W.S.
Total Common	5142.0000 C.W.S.
EARTH FILL	
Class B-2	182105.0000 C.W.S.

DIVERSIONS	
TECH SPEC 160	1499.0000 Lim Ft
TOTAL LENGTH	1499.0000 Lim Ft

PLAN	
STRUCTURE C-3	102 RIVER TRIM MAINTENANCE PL 566
NOBANDWAY COUNTY, MISSOURI	U.S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE	
Drawn by	N.H. Randall
Checked by	B.E. Smith
Scale	1" = 40'
Date	5.2.49
Project	5.2.49 552-P



NOTES
 1. The Top 2.1' Removed From The
 Foundation And Excavation To Be
 Within The Heat Lines And Below The
 Final Grades Of The Earth Fill And
 Emergency Spillway To A Depth Of
 Six (6) Inches To Be Paid For As Earth Fill.
 Plunge Basin Shall Not Be Taken
 Within 50 Feet Of The Top Of Fill
 Slopes. All Burrow Slopes Shall Be
 3:1 Unless Otherwise Specified.
 RIPRAP & FILTER BED To Cover The
 entire upstream slopes and berm
 between Elevations 1033.0 To 1086.0.

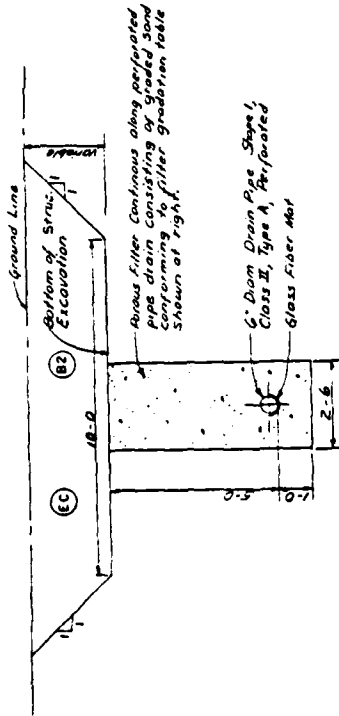
Note: Minor shaping and aligning
 of existing Channel may be
 required by the Engineer. This
 item is incidental to other
 items of the Contract.

PLAN

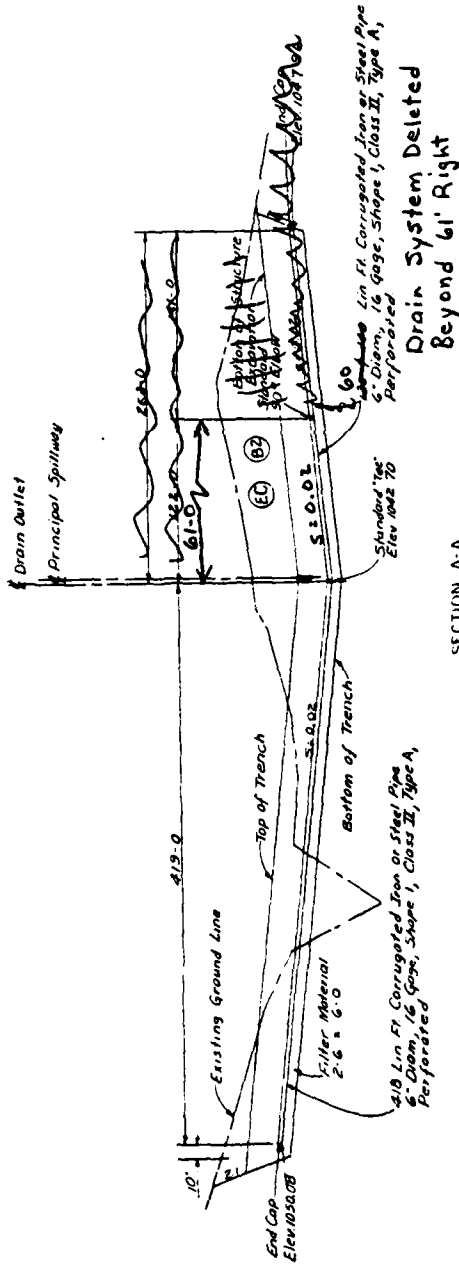
1" = 40'
 SCALE IN FEET

SILVER GRADATION	
SIZE	PASSING
7/8 IN.	100
NO. 4	85-100
NO. 10	60-100
NO. 20	30-85
NO. 40	15-40
NO. 60	5-15
NO. 100	0-10
NO. 200	0-5

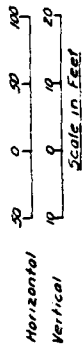
NOTE: The glass fiber mat shall be placed to cover the perforations in the Helical CM Pipe. The mat shall be similar in type and equal in quality to "Tie Guard" Type 3-20 as distributed by the Johns-Manville Corporation. Payment for the mat and installation will be made on a unit basis as indicated by the unit price and placement of the perforated pipe.



CROSS SECTION OF POROUS FILTER FOR 6" DIAM. PERFORATED HELICAL CM PIPE

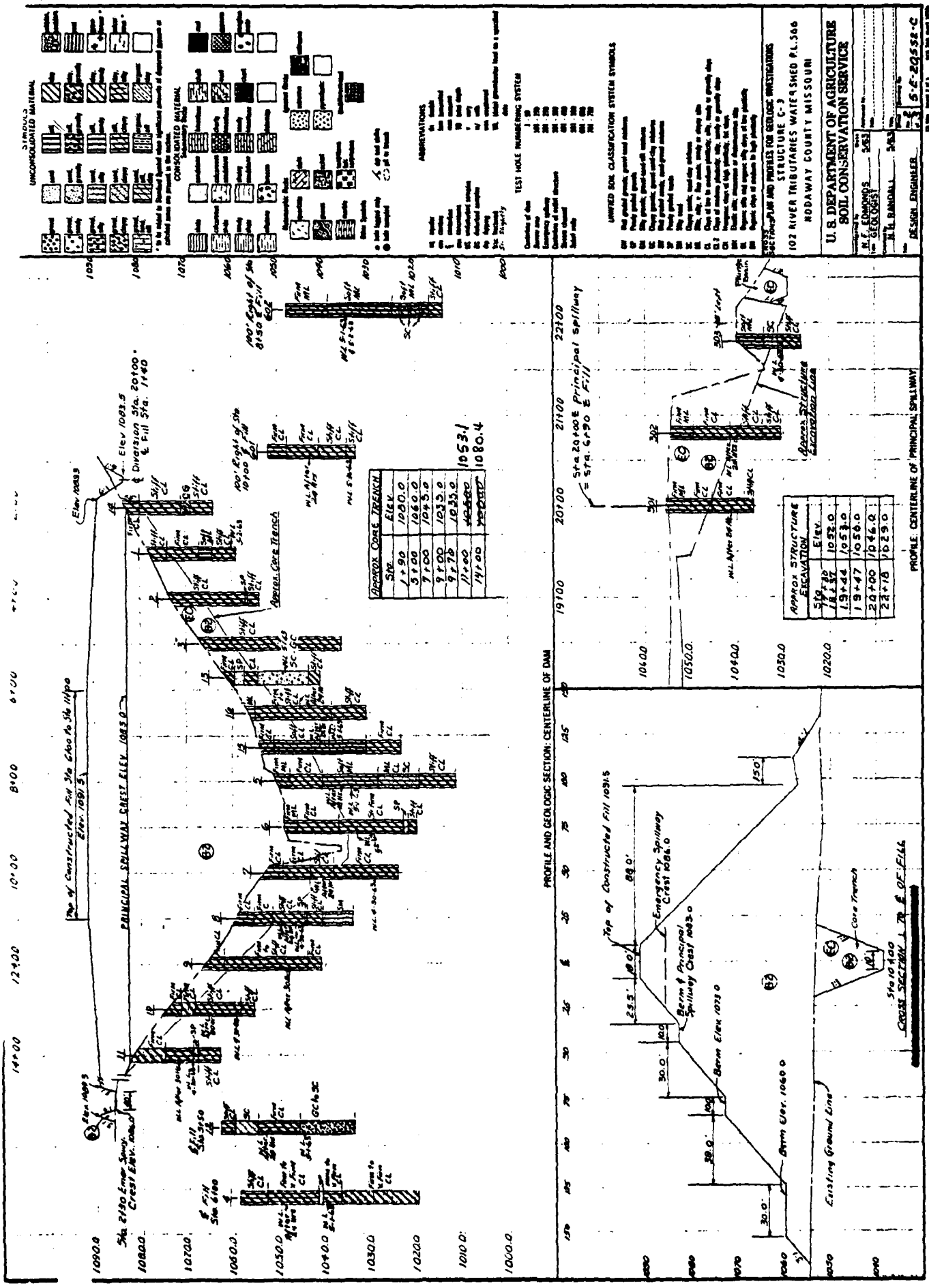


SECTION A-A
FOUNDATION TRENCH DRAIN SYSTEM



STRUCTURE C-3
FOUNDATION TRENCH DRAIN SYSTEM
102 RIVER TRIBE WATERSHED PL 566
NODAWAY COUNTY, MISSOURI
U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

Project No.	943
Drawn By	B. E. Smith
Check By	J. D. Naiman
Date	3/64
Scale	1/4" = 1'-0"
Sheet No.	5 of 20

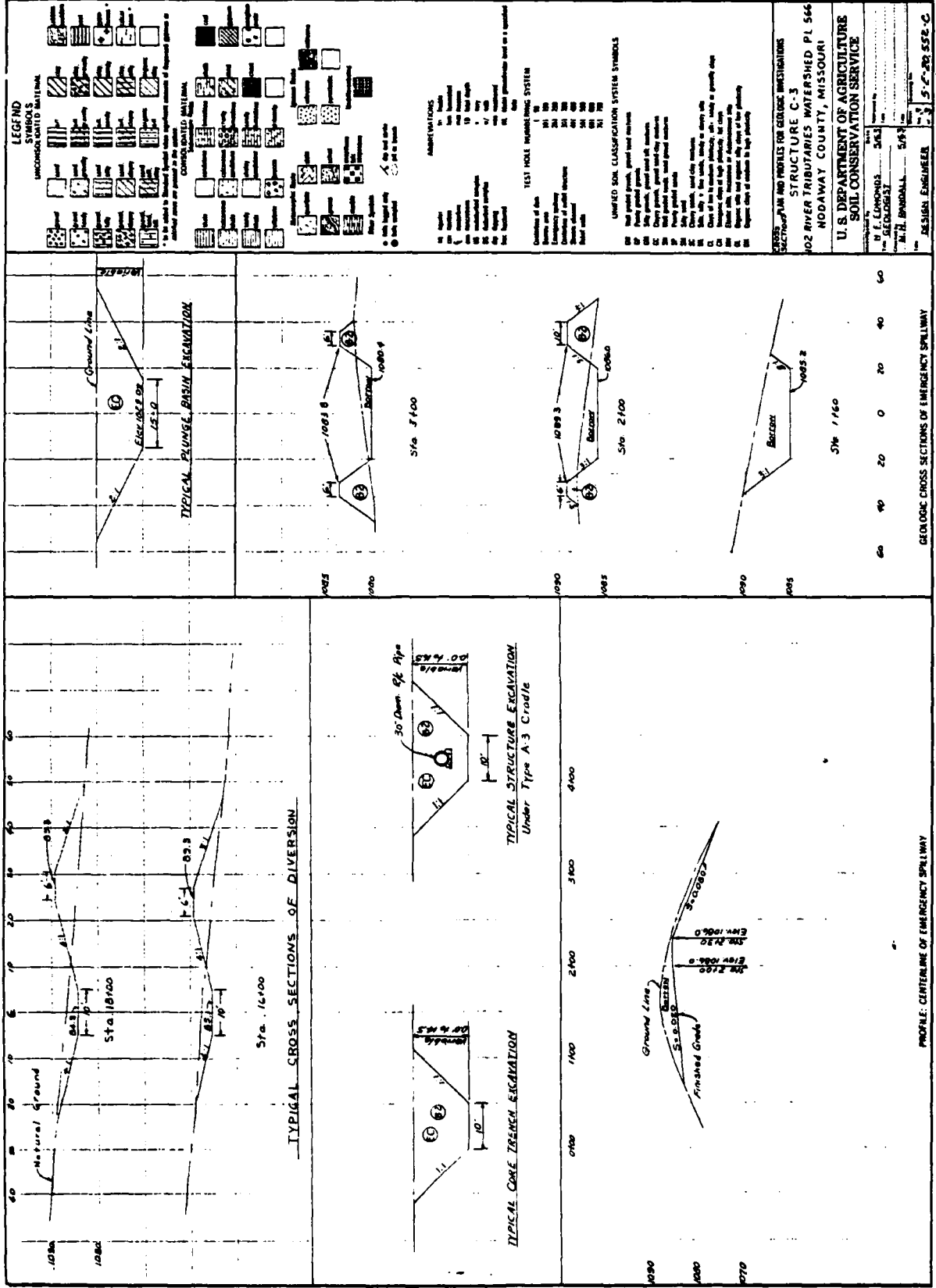


U.S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

102 RIVER TRIBUTARIES WATER SHED PL. 506
HODDWAY COUNTY MISSISSIPPI

STRUCTURE C-3
102 RIVER TRIBUTARIES WATER SHED PL. 506

DESIGN ENGINEER
N. F. RANDALL
5-2-20558-C



OFFICE MEMORANDUM -- UNITED STATES GOVERNMENT

TO : W. S. Culpepper, State Conservation Engineer, DATE: June 24, 1963
SCS, Columbia, Missouri

FROM : Roy S. Decker, Head, Soil Mechanics Laboratory,
SCS, Lincoln, Nebraska

SUBJECT: Missouri WP-3, 102 River Embankments, Site E0-1

RE : Preliminary Laboratory Report on Consolidation Along the Embankment
dated May 18, 1963

ATTACHMENTS

1. Form SCS 354, Soil Mechanics Laboratory Data, 4 sheets.
2. Form SCS 355, Triaxial Shear Test Data, 5 sheets.
3. Form SCS 352, Compaction and Penetration Resistance Report, 7 sheets.
4. Form SCS 357, Summary - Slope Stability Analysis, 3 sheets.

DISCUSSIONFOUNDATION MATERIALS:

- A. Classification: This site is located in a glacial till area. The till occurs at the surface on the upper portion of the abutments. Alluvial material mantles the till from about \pm Station 12+50 on the left abutment to about \pm Station 6+50 on the right abutment. The glacial till at this site is logged as firm to stiff and is primarily a CL. Localized lenses or strata of sandy material occur in the till throughout the investigational depth. The till in the area between \pm Station 5+50 and 6+50 appears to have the highest concentration of sandy material. In test hole 13 at \pm Station 5+75 sandy zones were encountered at the 2 to 4-foot depth and the 7 to 18-foot depth. The zone from 2 to 4 feet is logged as SP and the zone from 7 to 18 feet is logged as SC and GC. Material in the 7 to 18-foot zone appears to be quite variable however. Jar samples from this zone representing the material from 8 to 10 feet and from 12 to 14 feet classed as SP or SC-SM and SM-SP, respectively.

The alluvial material ranges from a few feet thick on the lower portion of the left abutment to a maximum thickness of about 30 feet at \pm Station 8+00. The alluvium can be separated into four general classes as follows. The surface 3 or 4 feet in the floodplain is logged as firm ML. On the right side of the channel a zone of high plasticity CL or CH underlies the ML. This zone of alluvium is represented by Samples 63W3597 and 63W3325 (core) from test hole 6, and by Samples 63W3824 (core) and 63W3608 from test holes 5 and 15, respectively. A zone of soft alluvium underlies the firm CL and CH zone from about the 10 to 22-foot depth in test hole 5. This soft zone appears to be continuous from about \pm Station 7+25 to about \pm Station 10+00. The thickness of this zone ranges from about 5 feet to a

2 -- W. S. Culpepper -- 6/24/63

Ray S. Decker

Subj: Missouri WP-08, 102 River Tributaries, Site No. C-3

maximum of 12 feet. Core Sample 63W3594 represents this zone. The soft CL zone directly overlies the till, except for the area at Station 8+00 where a 9-foot zone of stratified silts, clays, and fine sands were encountered on top of the till. A sample from this zone (63W3596) classifies as an SM-SW.

- B. Blow Count and Density: Blow count in the zone of firm alluvial CL and CH was in the range of 7 to 8 blows per foot. These tests, although above water table, appear to represent saturated material. Undisturbed samples from 2 to 3 feet above the zone of blow count had a moisture content in the range of 24% which is at 87% or more of theoretical saturation. The density of the material in this zone as represented by Samples 63W3824 and 63W3825 is about 96.0 p.c.f. The natural density of this material appears to be within 5 p.c.f. of maximum Standard density based on a comparison of samples with similar gradation and plasticity from the borrow area.

The zone of soft CL has a blow count of 4 or less blows per foot. Only one blow per foot was recorded in this zone in test hole 5. Core Sample 63W3594 from the soft alluvial zone had a density of about 94.0 p.c.f. to 97 p.c.f. This is a sandy CL and the natural density appears to be in the range of about 85% of Standard Proctor.

The stratified sandy zone underlying the soft CL zone in test hole 5 has blow count of from 6 to 11 and the blow count within the till is generally in the range of 8 to 13 blows per foot.

A core sample from the 19 to 21-foot depth in test hole 6 was from a zone of CL logged as slightly firm. A blow count test from this zone showed 5 blows per foot. The core had a density of from 87.5 p.c.f. to 91 p.c.f. The material is a high plasticity CL. The unconfined compressive strength, the preconsolidation pressure indicated by the consolidation test and the general appearance of the material suggest that the zone represented by this core may actually be till rather than alluvium.

- C. Shear Strength: The shear strength of the various foundation materials as indicated by triaxial tests on undisturbed samples are as follows.

- (1) $\phi = 21^\circ$, $c = 600$ p.s.f. for the high plasticity, firm alluvium.
- (2) $\phi = 16.5^\circ$, $c = 175$ p.s.f. for the zone logged as soft alluvium.
- (3) $\phi = 16^\circ$, $c = 300$ p.s.f. is considered to represent the minimum strength of the firm, glacial till.

Based on blow count tests, the stratified alluvial zone, as shown in test hole 5, is expected to have shear strength equivalent to that obtained on Sample 63W3598 (till).

Rey S. Decker

Subj: Missouri WP-08, 102 River Tributaries, Site No. C-3

- D. Consolidation: Consolidation tests were made on core Samples 63W3594 and 63W3593. The consolidation estimate at the conduit location (± 6+90) was reported May 18, 1963.

Total consolidation for the floodplain section is estimated as follows:

- (1) The thin zone of surface ML will be largely removed or disturbed and compacted during site preparation; therefore, the consolidation potential within this zone should be negligible.
- (2) The firm CL or CH alluvial zone has a relatively high density. The consolidation potential of this material should not exceed that of borrow Sample 63W3615. The test density of 63W3615 was 95.5 p.c.f., which is about equivalent to the natural density of the material in this zone. Borrow Sample 63W3615 is a high plasticity CL that is comparable to the material in this zone. The consolidation potential within the firm CL or CH alluvial zone under the proposed loading is estimated to be 2% or about 0.2 foot.
- (3) Sample 63W3594 is considered representative of the soft CL alluvial zone. Consolidation potential within this zone under the proposed loading is estimated to be about 8 percent or 0.9 foot.
- (4) The preconsolidation pressure of the till as shown by Sample 63W3598 is in excess of the proposed load; therefore, the till is considered as incompressible.
- (5) The blow count in the stratified silt, clay and fine sand layer in test hole 5 is quite high and this zone is also considered as incompressible.

The total consolidation within the floodplain section is estimated to be 1.1 feet.

- E. Permeability: The permeability of all materials, except the relatively clean sands (SM-SW and SM-SP), is expected to be very low. Based on the D_{10} size, the sands represented by Samples 63W3596 and 63W3607 are expected to have permeability rates in the range of 2 feet per day. This estimate is based on Hazen equation for permeability and effective size and includes a correction for the D_u size.

EMBANKMENT MATERIALS:

- A. Classification: The borrow samples submitted are classed as CL. The Liquid Limits of these materials range from 39 to 47 and PI values range from 15 to 27.
- B. Compacted Density: Standard Proctor compaction tests were made on all of the borrow samples submitted. The compacted densities obtained ranged from 98 p.c.f. to 109 p.c.f.

-- W. S. Culpepper -- 6/24/63

Ray S. Decker

Subj: Missouri WF-08, 102 River Tributaries, Site No. C-3

- C. Shear Strength: Triaxial shear tests were made on borrow Sample 63W3594. The test was made at 95% of Standard Proctor density at saturation and is considered to represent the glacial till samples submitted. The till samples represent the largest volume of borrow material.

Shear values obtained were $\phi = 8.5^\circ$ and $c = 650$ p.s.f.

SLOPE STABILITY:

The stability of the proposed embankment was checked with a modified Swedish circle method of analysis. The analysis was made for the floodplain section (E Station 8+50), the maximum embankment section and a section at the principal spillway location. A phreatic line from emergency spillway elevation was assumed. The following shear strength values were used for the different materials along the assumed failure arcs.

- (1) Embankment - $\phi = 8.5^\circ$, $c = 650$ p.s.f.
- (2) Firm surface alluvium - $\phi = 21^\circ$, $c = 600$ p.s.f. This zone was considered as 9 feet thick in the floodplain and also at the principal spillway location.
- (3) Soft alluvial zone - $\phi = 16.7^\circ$, $c = 175$ p.s.f. This zone was considered as 12 feet thick in the floodplain and 9 feet thick at the principal spillway location.

A summary of the stability analyses is attached (Forms EOC 557). The limiting slopes and bents are shown in the following table.

Section	Slope	E	Bents		Drain Location	Width No.	Factor
			Width	Elevation			
Floodplain Upstream	3:1		10'	1084.7		52	1.35
			10'	1075.0			
			10'	1060.0			
Floodplain Upstream	3:1		10'	1084.7		7	1.35
			10'	1072.0			
			10'	1060.0			
Floodplain Downstream	2 1/2:1/4:1	15'	15'	1060.0	c/b = 0.6	11	1.35
Floodplain Downstream	2 1/2:1/4:1	15'	15'	1060.0	c/b = 0.3	10	1.35

RECOMMENDATIONS

- A. Centerline Cutoff: The following cutoff trench depths are suggested.

5 -- W. S. Culpepper -- 6/24/63

Rey S. Decker

Subj: Missouri WP-08, 102 River Tributaries, Site No. C-3

Station	Trench Depth, Feet	Bottoms In
2+00	6.0	CL Till
3+00	6.0	CL Till
4+00	6.0	CL Till
5+00	6.0	CL Till
5+50	8.0	CL Till
6+00	6.0	CL Till
8+00	6.0	CH Alluvium
9+00	6.0	CL or CH Alluvium
10+00	6.0	CL Alluvium
11+00	6.0	CL Alluvium
12+00	6.0	CL Till
13+00	7.0	CL Till
14+00	7.0	CL Till

The 6.0-foot minimum depth is suggested to insure that the trench bottoms below the zone affected by drying cracks.

It appears that a deep trench in the range of 15 to 18 feet would be required to cut off the sandy lenses at Station 5+75. As an alternative to a deep trench at this location, a shallow trench (6.0 feet) with a deep trench drain could be used for this section.

The trench should be backfilled with CF and compacted to a minimum of 95 percent of Standard Proctor Density.

B. Principal Drilling: See preliminary report dated May 18, 1963.

C. Drain: A drain is required for embankment stability with the proposed 2 1/2:1 over 4:1 downstream slope with a 15-foot berm at elevation 1060. In view of the sandy lenses that appear to occur intermittently, a drain is considered desirable for the foundation also.

A foundation trench drain is suggested since it will control the phreatic line within the embankment and also provide protection against piping. The drain location will depend somewhat on the desired factor of safety of the downstream slope. For a Class A embankment, the drain can be located at $c/y = 0.5$ ($y = 1.5$). For a Class B or C dam, the drain should be located at about $c/y = 0.5$ in order to obtain a factor of safety in the range of 1.5. The drain should extend up the abutments to about elevation 1060. The trench should penetrate the foundation about 6 feet, except in the area of Station 5+75 where a trench depth of at least 12 feet is suggested.

A designed filter is not required for the drain. The exception to this may be in the area of Station 5+75 (test hole 13) where the drain material will be in contact with the sandy lenses or strata. Any reasonably well-graded, clean sand-gravel mixture may be used for the drain

6 -- W. S. Culpepper -- 6/24/63
Ray S. Decker
Subj: Missouri WP-08, 102 River Tributaries, Site No. C-3

where the drain will be in contact with CL. For the sandy areas where the drain will be in contact with materials like the SM and SM-SP strata in test hole 13, a designed filter should be used.

D. Embankment Design:

1. Placement of Materials: A homogeneous embankment of CL material is recommended. The embankment material should be placed at a minimum of 95 percent of Standard Proctor density. The placement moisture content should be maintained at optimum or above.
2. Slopes: The following slopes have satisfactory factors of safety and are recommended.

- A. Upstream: 3:1 with 10-foot berms at elevation 1084.7 and 1073 and a 30-foot berm at elevation 1060.

Where the 24-foot berm is required around the inlet (Elevation 1084.7), the upstream slope could be modified as follows: 3:1 with a 24-foot berm at elevation 1084.7; a 10-foot berm at elevation 1073; and a 20-foot berm at elevation 1060.

- B. Downstream: 2 1/2:1 above with a 15-foot berm at elevation 1060 and a 4:1 slope below the berm.

3. Settlement: An overfill allowance of 1.75 feet is suggested to compensate for residual consolidation within the foundation and the embankment.

Prepared by:

Lorn P. Dunnigan

Reviewed and Approved by:

Roland B. Phillips

Attachments

cc: W. S. Culpepper (2)
H. J. Behrens, Milwaukee, Wisconsin
Harold Townsend, Bethany, Missouri (2)

-336-020

May 22, 1963

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE[illegible]

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE[illegible]

May 7, 1963

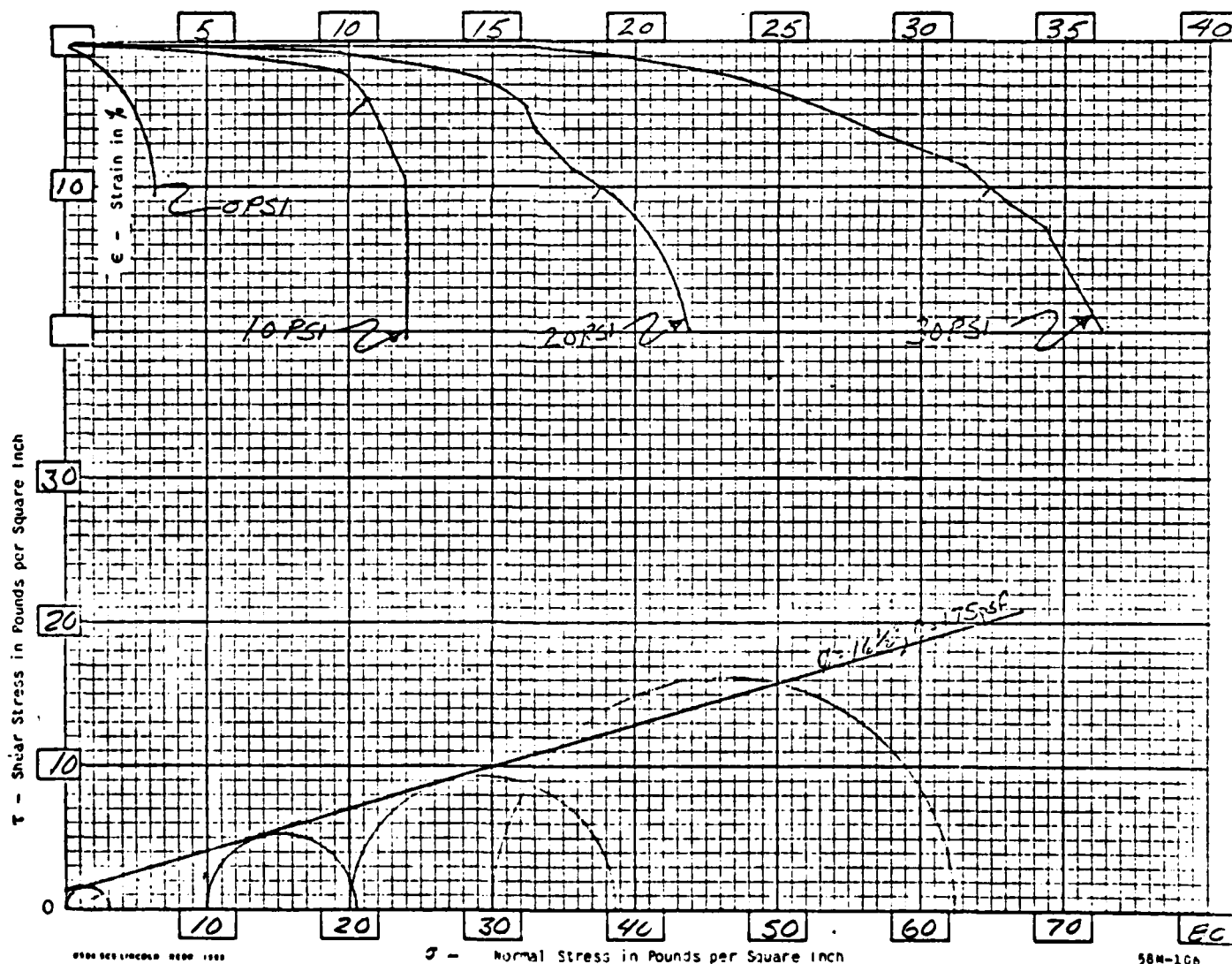
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SOIL MECHANICS LABORATORY
TRIAXIAL SHEAR TEST DATASample Number 63W2594Project 102 RIVER TRIBUTARIESLocation MISSOURI

Moisture-Density Data		Specifications:	
Standard <input type="checkbox"/>	Max. γ _____ pcf	Specimen: _____	<input checked="" type="checkbox"/> Consolidated <input type="checkbox"/> Drained
Modified <input type="checkbox"/>	Optimum _____	Height <u>3.0</u> "	<input type="checkbox"/> Unconsolidated <input checked="" type="checkbox"/> Undrained
Curve No. _____ of _____	Moisture _____ %	Size <u>< #10</u>	Diameter <u>1.4</u> " Material _____
L.L. <u>51</u> P.L. <u>14</u> Class <u>CL</u> G _s <u>2.65</u>		<input checked="" type="checkbox"/> Undisturbed and Tested at: <input checked="" type="checkbox"/> Natural Moisture <input type="checkbox"/> Saturation	
% Finer Than: 0.002mm <u>18</u> 0.005mm <u>25</u> #200 <u>69</u>		<input type="checkbox"/> Remolded and Tested at: _____ % of <input type="checkbox"/> Standard <input type="checkbox"/> Modified	
Other Factors Affecting Shear:		with w = _____ % which is	
% Dispersion <u>24</u> % Salt _____		<input type="checkbox"/> Lower than Optimum <input type="checkbox"/> Optimum <input type="checkbox"/> Higher than Optimum <input type="checkbox"/> Saturated	
Other: _____			

BEFORE		AFTER		Moisture Content		Lateral Pressure σ_3	Consolidation Data		Stress at Failure $\sigma_1 - \sigma_3$	% Strain at Failure ϵ	Internal Friction ϕ Tan ϕ	Unit Cohesion
Dry Density γ pcf	% Max. Dry Den.	Start %	% Sat. Start	End %	Orig. e_0		Final e_f					
1.52		27.7	92.2	27.4	0	.7501		3.2	9.2	ϕ_0 16 1/2	1.2 psi	
1.52	1.56	27.9	98.9	25.6	10	.7501	.7050	10.6	4.0			
1.44	1.52	28.9	90.9	24.5	20	.8471	.7501	18.7	10.0	Tan ϕ	175 psf	
1.57	1.69	25.9	99.2	21.1	30	.6743	.5741	32.4	10.0			

 $\sigma_1 - \sigma_3$ in Pounds per Square Inch

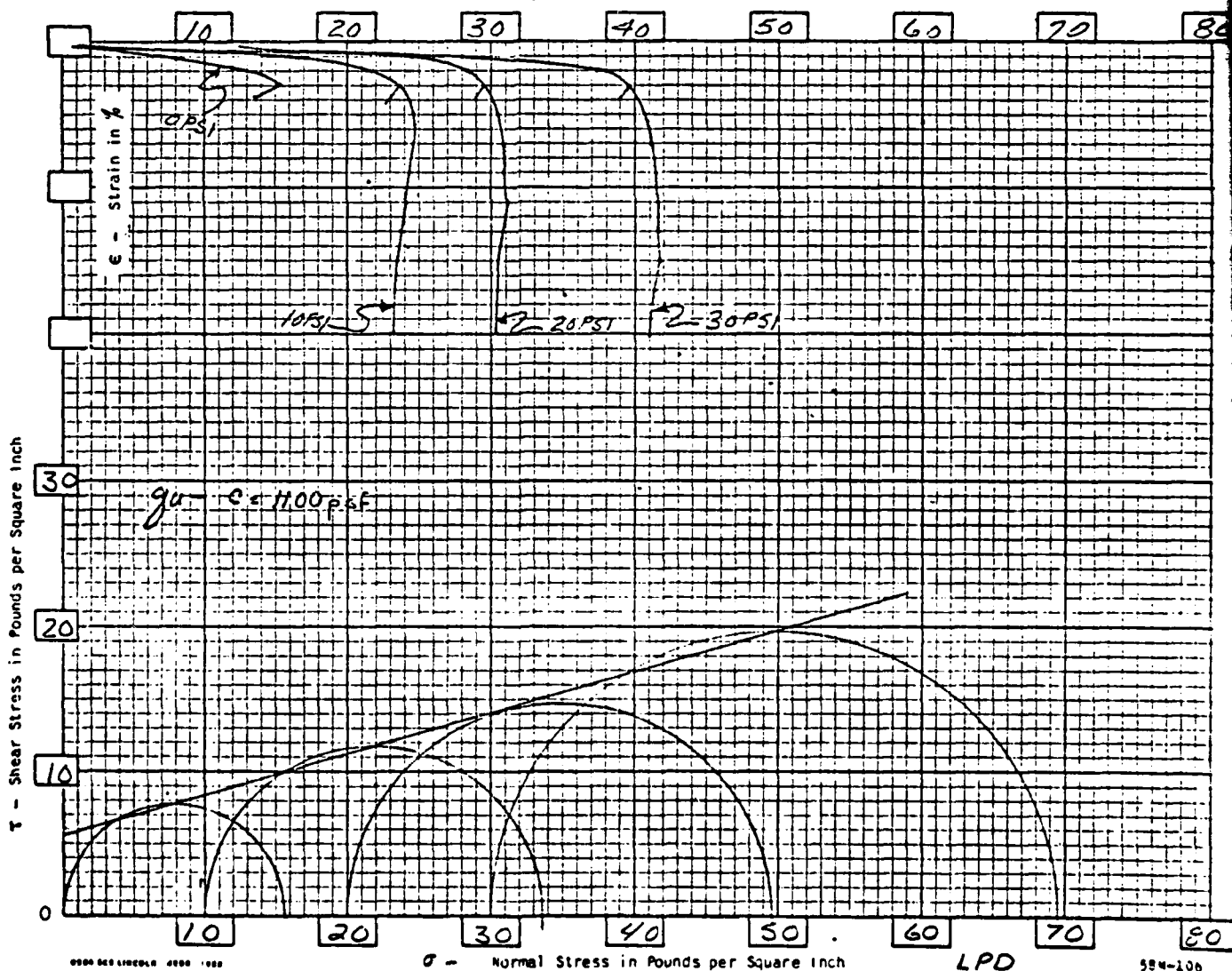
U. S. DEPARTMENT OF AGRICULTURE
 SOIL CONSERVATION SERVICE
 SOIL MECHANICS LABORATORY
 TRIAXIAL SHEAR TEST DATA
Sample Number 63W3592

Project _____

Location _____

Moisture-Density Data Standard <input type="checkbox"/> Max. γ _____ pcf Modified <input type="checkbox"/> Optimum _____ Curve No. _____ of _____ Moisture _____ % L.L. <u>46</u> P.L. <u>24</u> Class <u>CL</u> G_s <u>2.68</u> % Finer Than: 0.002mm <u>20</u> 0.005mm <u>35</u> #200 <u>24</u> Other Factors Affecting Shear: % Dispersion <u>31</u> % Salt _____ Other: _____		Specifications: Specimen: _____ Max. <input checked="" type="checkbox"/> Consolidated <input type="checkbox"/> Drained Height <u>3.0</u> Size <u>#10</u> <input type="checkbox"/> Unconsolidated <input checked="" type="checkbox"/> Undrained Diameter <u>1.4</u> Material _____ Undisturbed and Tested at: <input checked="" type="checkbox"/> Natural Moisture <input type="checkbox"/> Saturation Remolded and Tested at: _____ % of <input type="checkbox"/> Standard <input type="checkbox"/> Modified with $w =$ _____ % which is <input type="checkbox"/> Lower than Optimum <input type="checkbox"/> Optimum <input type="checkbox"/> Higher than Optimum <input type="checkbox"/> Saturated Optimum	
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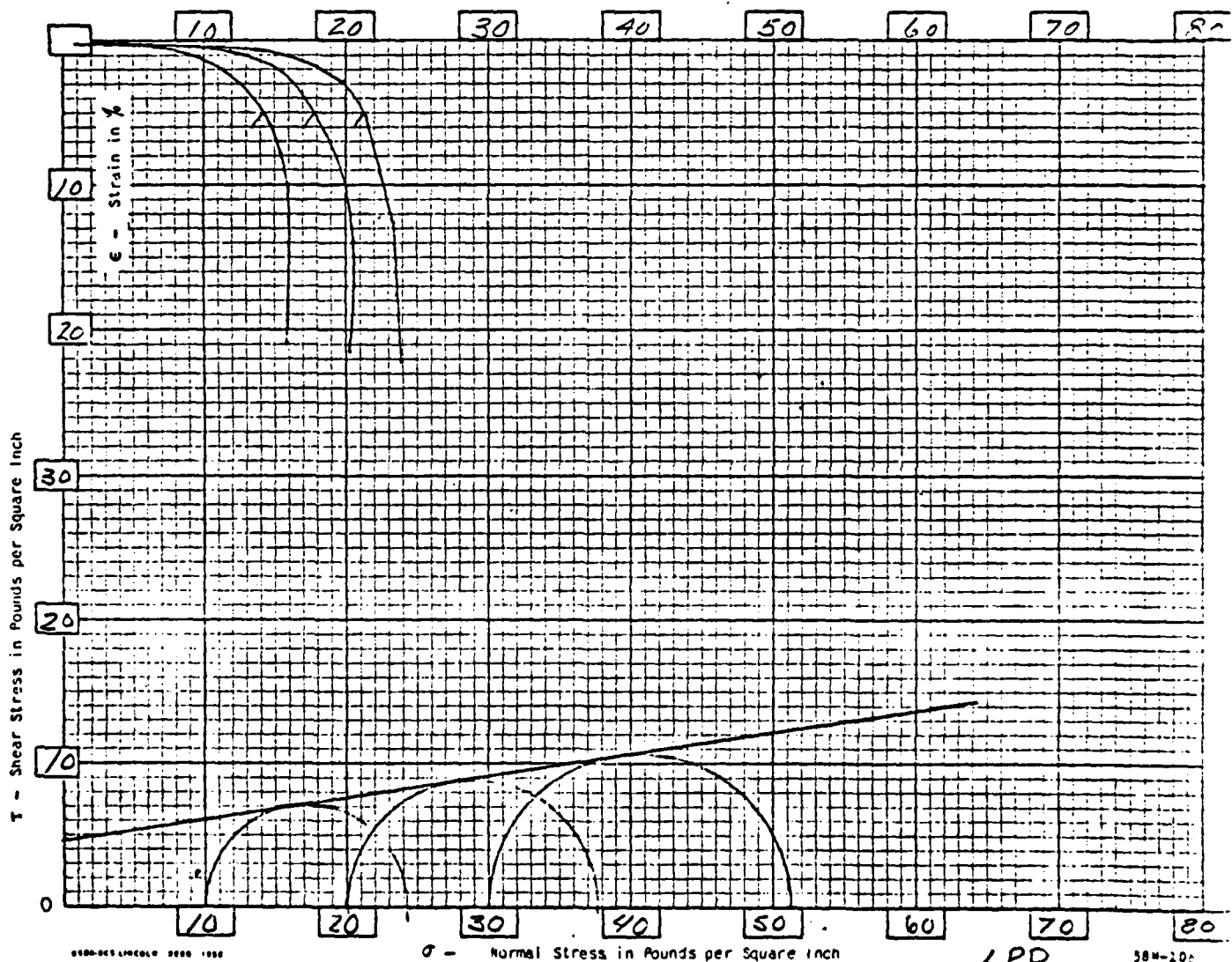
Test Data											
Dry Density γ pcf	% Max. Dry Den.	Moisture Content			Lateral Pressure σ_3	Consolidation Data		Stress at Failure $\sigma_1 - \sigma_3$	% Strain at Failure ϵ	Internal Friction ϕ Tan ϕ	Unit Cohesion
		Start %	% Sat. Start	End %		Orig. e_0	Final e_f				
1.46		30.8	98.7	30.9	0	.8355		15.3	3.0	ϕ	
1.39	1.41	33.7	97.4	34.2	10	.9279	.9008	23.7	3.0	ϕ	55 psi
1.38	1.42	34.5	98.0	33.5	20	.9121	.8871	29.5	3.0	16°	800 psf
1.45	1.48	30.9	97.5	30.1	30	.8484	.8107	39.6	3.0	Tan ϕ	

 $\sigma_1 - \sigma_3$ in Pounds per Square Inch

TRIAXIAL SHEAR TEST DATA

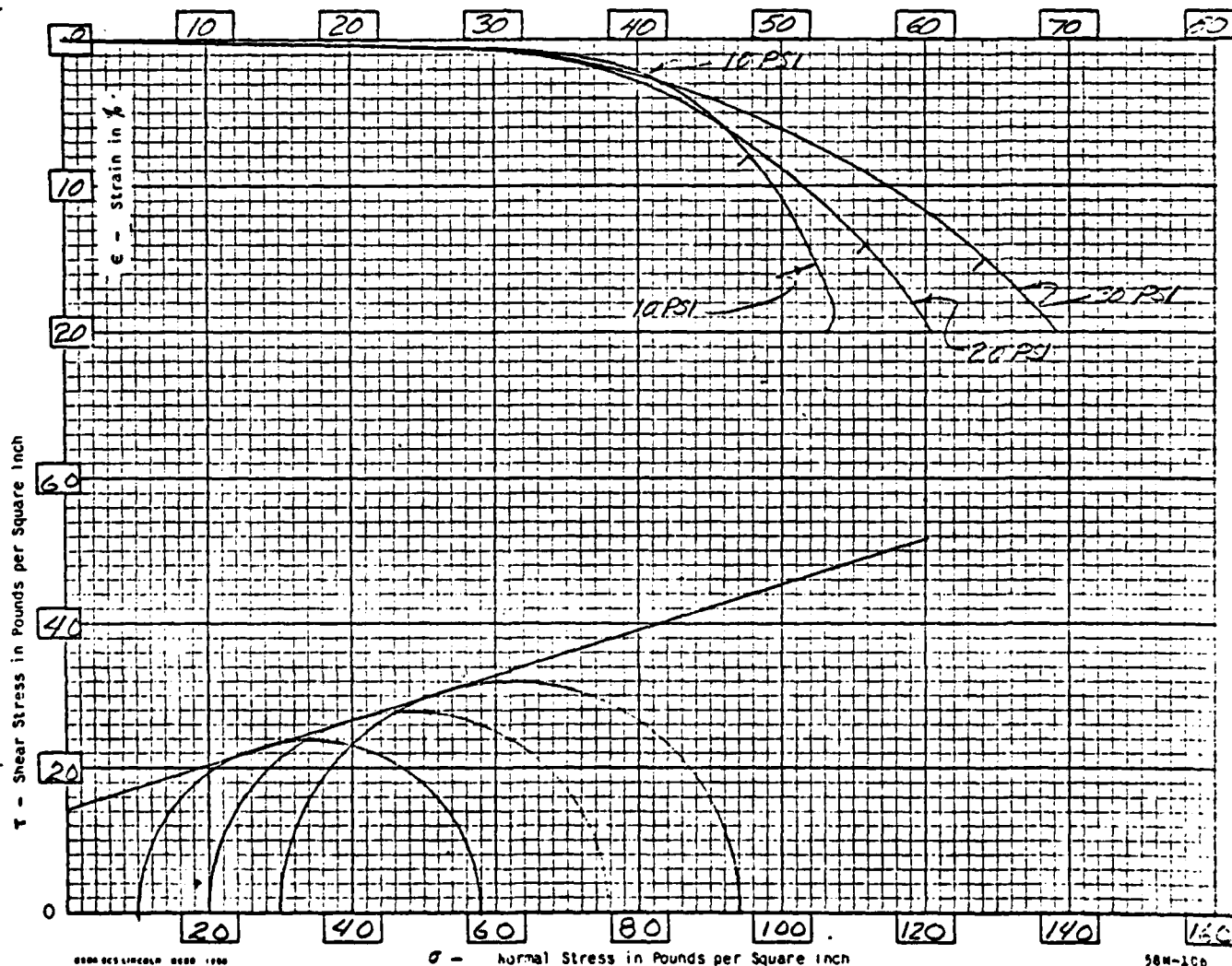
Project 102 River Trib. Site C-3 Location Missouri

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Modified <input type="checkbox"/>	Optimum Moisture <u>16.5</u> %			Height <u>3.0</u> "	Size <u>< #10</u>	<input type="checkbox"/> Unconsolidated	<input checked="" type="checkbox"/> Undrained				
Curve No. <u>1</u> of <u> </u>				Diameter <u>1.4</u> "	Material						
L.L. <u>46</u> P.L. <u>27</u> Class <u>CL</u> G. <u>2.66</u>				<input type="checkbox"/> Undisturbed and Tested at: <input type="checkbox"/> Natural Moisture <input type="checkbox"/> Saturation							
% Finer Than: 0.002mm <u>34</u> 0.005mm <u>39</u> #200 <u>72</u>				<input checked="" type="checkbox"/> Remolded and Tested at: <u>95</u> % of <input checked="" type="checkbox"/> Standard <input type="checkbox"/> Modified							
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% Dispersion <u> </u> % Salt <u> </u>				<input type="checkbox"/> Lower than Optimum <input type="checkbox"/> Optimum <input type="checkbox"/> Higher than Optimum <input checked="" type="checkbox"/> Saturated							
Other: <u>Molded at Saturation</u>											
Test Data											
Dry Density γ pcf	% Max. Dry Den.	Moisture Content			Lateral Pressure σ_3	Consolidation Data		Stress at Failure $\sigma_1 - \sigma_3$	% Strain at Failure ϵ	Internal Friction ϕ Tan ϕ	Unit Cohesion
		Start %	% Sat. Start	End %		Orig. e_0	Final e_f				
99.8	94.2	24.3	97.6	24.0	10	.6625	.6625	14.2	5.0	ϕ <u>8.5</u> ^o Tan ϕ	<u>4.5</u> psi <u>650</u> psf
99.8	94.2	24.3	97.6	23.3	20	.6625	.6121	17.8	5.0		
100.5	94.8	24.2	98.8	22.9	30	.6521	.5647	21.2	5.0		

 $\sigma_1 - \sigma_3$ in Pounds per Square Inch

U. S. DEPARTMENT OF AGRICULTURE
 SOIL CONSERVATION SERVICE
 SOIL MECHANICS LABORATORY
 TRIAXIAL SHEAR TEST DATA
Sample Number 63W3513Project 102 River Tr. 6 Site C-3 Location Missouri

Moisture-Density Data				Specifications:							
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Modified <input type="checkbox"/>	Optimum Moisture <u>17.0</u> %			Height <u>30</u> Size <u>4#10</u>	<input type="checkbox"/> Unconsolidated	<input type="checkbox"/> Undrained					
Curve No. <u> </u> of <u> </u>				Diameter <u>1.4</u> Material <u> </u>							
L.L. <u>46</u> P.L. <u>27</u> Class <u>CL</u> G_s <u>2.66</u>				<input type="checkbox"/> Undisturbed and Tested at: <input type="checkbox"/> Natural Moisture <input type="checkbox"/> Saturation							
% Finer Than: 0.002mm <u>34</u> 0.005mm <u>39</u> #200 <u>72</u>				<input checked="" type="checkbox"/> Remolded and Tested at: <u>95</u> % of <input checked="" type="checkbox"/> Standard <input type="checkbox"/> Modified							
Other Factors Affecting Shear:				with $w =$ <u>17.0</u> % which is							
% Dispersion <u> </u> % Salt <u> </u>				<input type="checkbox"/> Lower than Optimum <input checked="" type="checkbox"/> Optimum <input type="checkbox"/> Higher than Optimum <input type="checkbox"/> Saturated							
Other: <u> </u>											
Test Data											
Dry Density γ pcf	% Max. Dry Den.	Moisture Content			Lateral Pressure σ_3	Consolidation Data		Stress at Failure $\sigma_1 - \sigma_3$	% Strain at Failure ϵ	Internal Friction ϕ Tan ϕ	Unit Cohesion
		Start %	% Sat. Start	End %		Orig. e_0	Final e_f				
99.8	95.0	16.3		16.0	10			47.8	8	ϕ	14 psi 1950 psi
99.2	94.5	16.2		15.9	20			55.8	14	17 1/2°	
100.5	95.7	16.2		15.9	30			64.0	15	Tan ϕ	

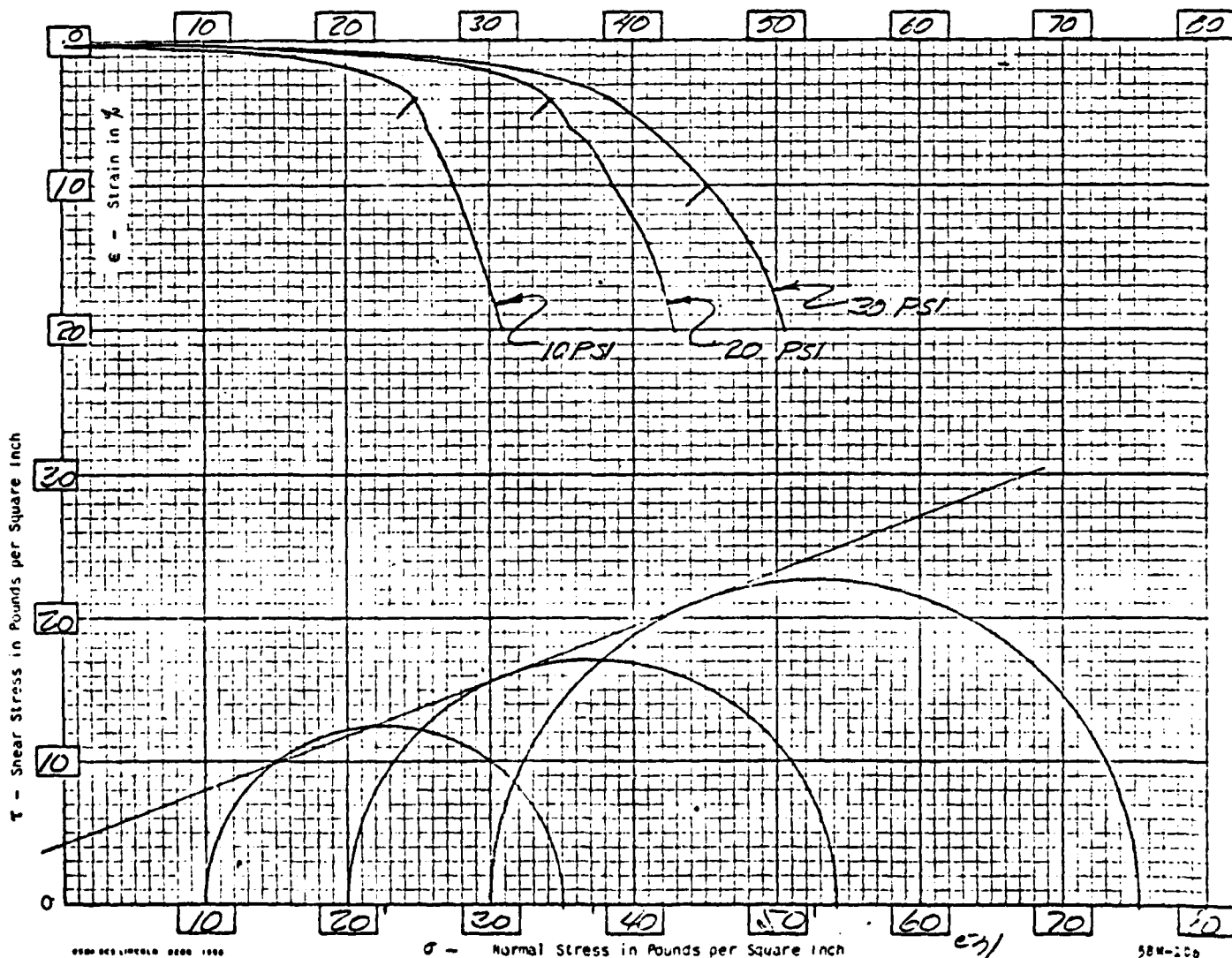
 $\sigma_1 - \sigma_3$ in Pounds per Square Inch

TRIAXIAL SHEAR TEST DATA

Project 112 Bar Tris. Site C-3Location Mo.

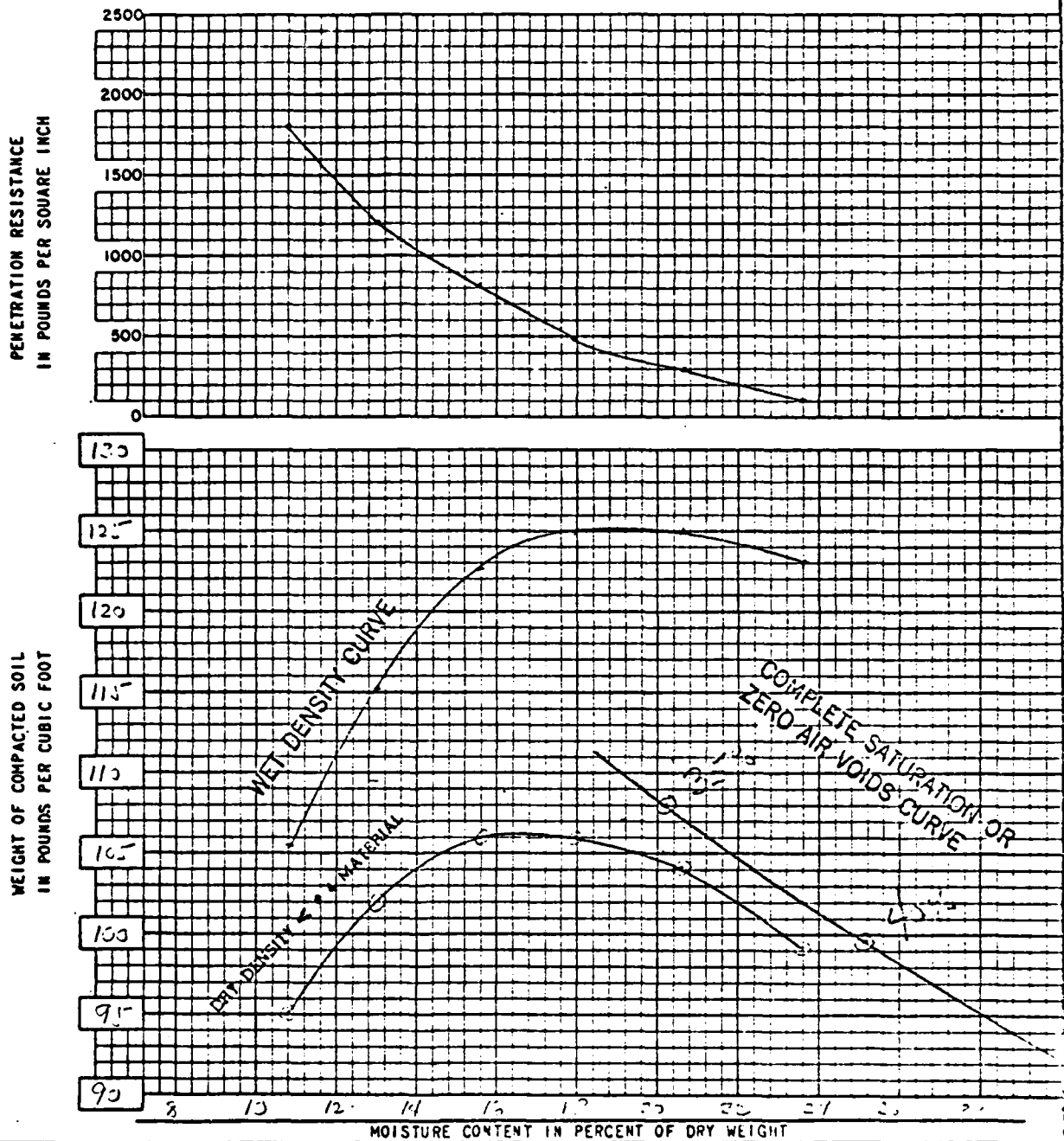
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L.L. <u>57</u> P.L. <u>34</u> Class <u>CH</u> G_s <u>2.66</u>		<input checked="" type="checkbox"/> Undisturbed and Tested at: <input type="checkbox"/> Natural Moisture <input checked="" type="checkbox"/> Saturation	
% Finer Than: 0.002mm <u>37</u> 0.005mm <u>42</u> #200 <u>55</u>		<input type="checkbox"/> Remolded and Tested at: _____ % of <input type="checkbox"/> Standard <input type="checkbox"/> Modified	
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% Dispersion <u>16</u> % Salt _____		<input type="checkbox"/> Lower than Optimum <input type="checkbox"/> Optimum <input type="checkbox"/> Higher than Optimum <input type="checkbox"/> Saturated	
Other: _____			

Initial		Final		Test Data							
Dry Density gm/cc pcf	Moist. γ pcf	Moisture Content			Lateral Pressure σ_3	Consolidation Data		Stress at Failure $\sigma_1 - \sigma_3$	% Strain at Failure ϵ	Internal Friction ϕ Tan ϕ	Unit Cohesion
		Start %	% Sat. Start	End %		Orig. e_0	Final e_f				
1.55	1.59	26.8	99.6	25.3	10	0.7161	0.6730	74.9	44	ϕ	4.2 psi 600 psf
1.55	1.61	26.9	100.0	24.6	20	0.7161	0.6522	34.2	44	21°	
1.53	1.61	26.9	96.8	23.8	30	0.7353	0.6522	45.3	10	Tan ϕ	

 $\sigma_1 - \sigma_3$ in Pounds per Square Inch

COMPACTION AND PENETRATION RESISTANCE REPORT

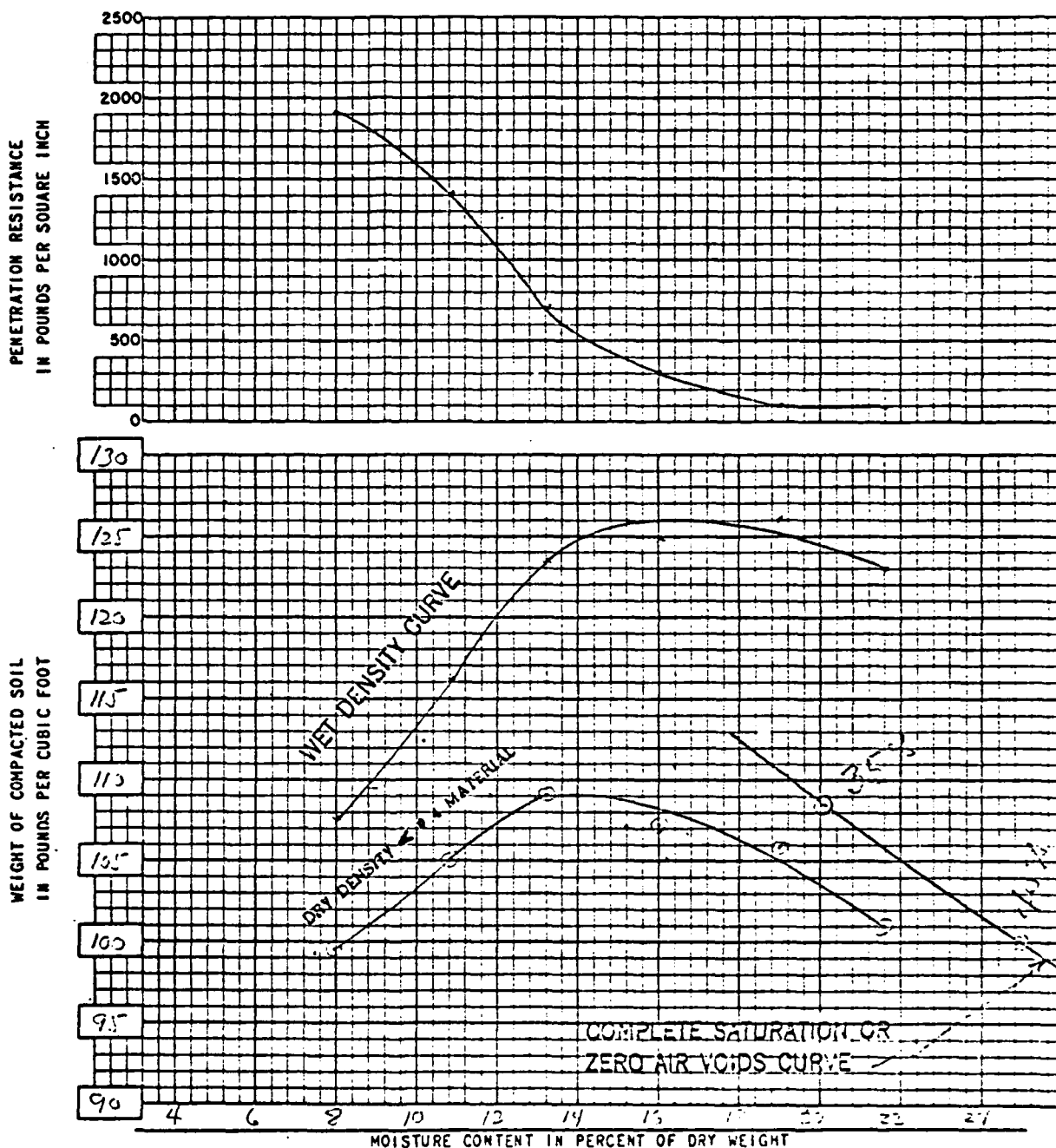
Date _____ Sample No.: Field _____ Lab 63W3612
 Project 102 RIVER TRIBUTARIES "C-3" Location MISSOURI
 Sample Location and Depth _____
COMPOSITE DEPTH 1-6'



TYPE OF TEST <input checked="" type="checkbox"/> Standard Proctor <input type="checkbox"/> Modified AASHTO <input type="checkbox"/> Other _____	TEST PROCEDURE Weight of Hammer <u>5.5</u> Lbs. Drop <u>12</u> Inches Lifts <u>3</u> Vol. of Cylinder <u>1/30</u> Cu. Ft.	Classification <u>CL</u> Material compacted represents <u>100</u> percent of the sample and passed <u>#4</u> sieve (Sp. Gr.) $G_s =$ <u>2.66</u> Curve <u>1 of 7</u>
---	--	--

COMPACTION AND PENETRATION RESISTANCE REPORT

Date _____ Sample No.: Field _____ * Lab 63013614
 Project 102 RIVER TRIBUTARIES #C-2 Location MISSOURI
 Sample Location and Depth * COMPOSITE DEPTH 6-12'



TYPE OF TEST

- ☒ Standard Proctor
☐ Modified AASHO
☐ Other _____

TEST PROCEDURE

Weight of Hammer 5.5 Lbs.
 Drop 12 Inches
 Lifts 3
 Vol. of Cylinder 1/3 Cu.Ft.

Classification

CL

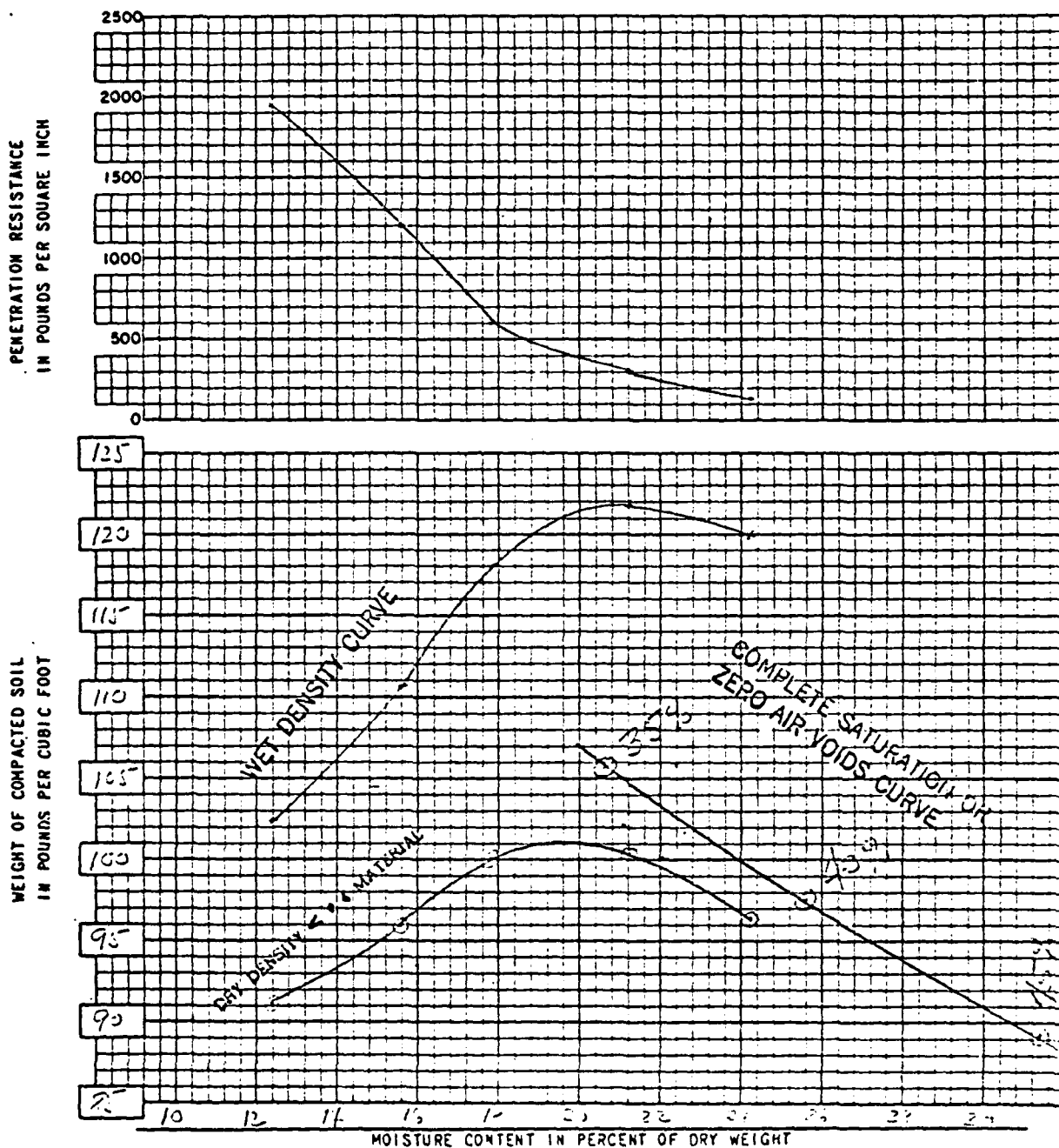
Material compacted represents
100 percent of the sample
 and passed #4 sieve

(Sp. Gr.) $G_s =$ 2.67

Curve 2 of 7

COMPACTION AND PENETRATION RESISTANCE REPORT

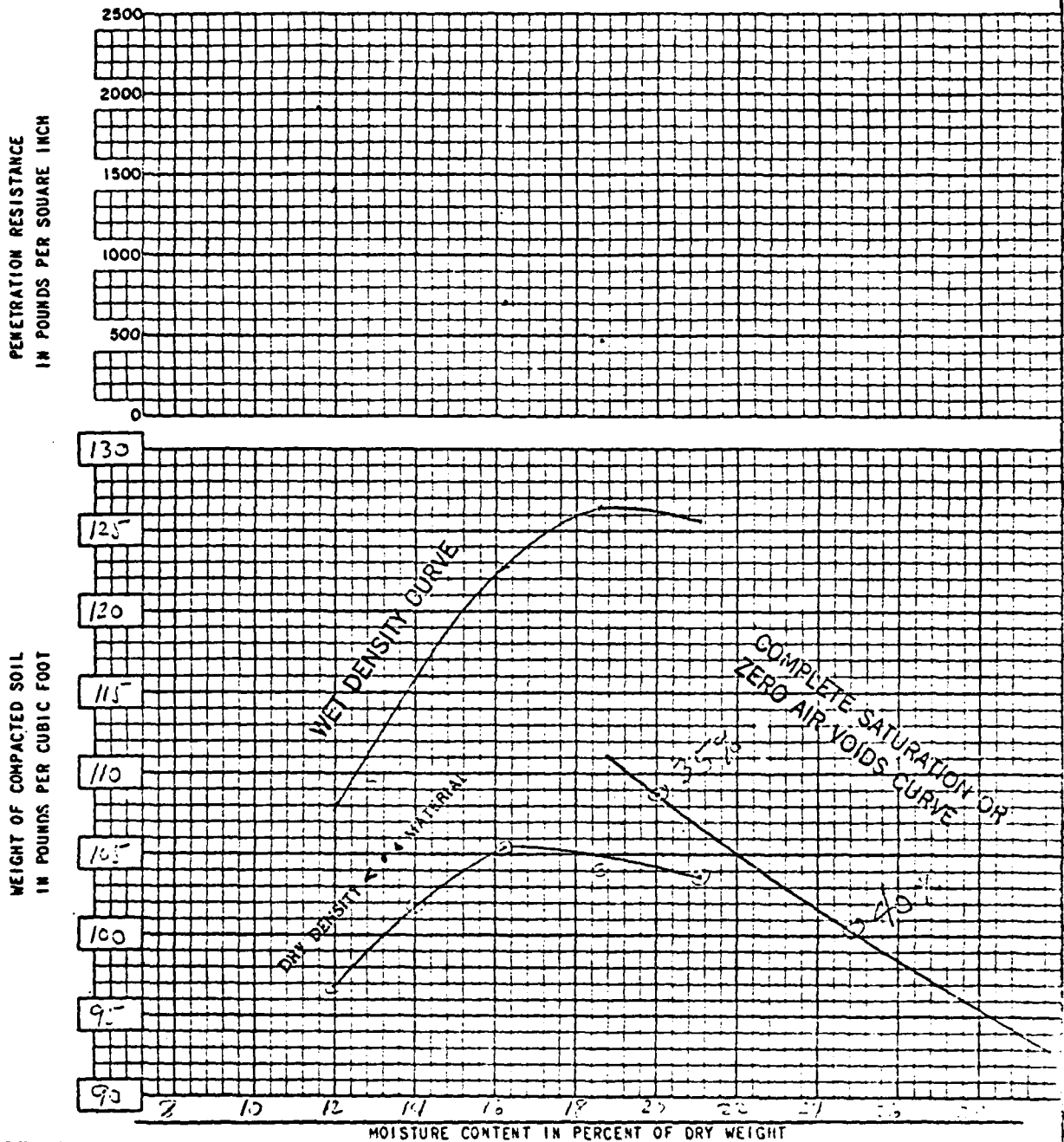
Date _____ Sample No.: Field 104-1 Lab 63W3615
 Project 102 RIVER TRIBUTARIES C-2 Location MISSOURI
 Sample Location and Depth Bottom D+20 7+60 Depth 1-7'



TYPE OF TEST <input checked="" type="checkbox"/> Standard Proctor <input type="checkbox"/> Modified AASHO <input type="checkbox"/> Other _____	TEST PROCEDURE Weight of Hammer <u>5.5</u> Lbs. Drop <u>12</u> Inches Lifts <u>3</u> Vol. of Cylinder <u>1/30</u> Cu. Ft.	Classification <u>CL</u> Material compacted represents <u>100</u> percent of the sample and passed <u>N₄</u> sieve (Sp. Gr.) <u>G_s = 2.61</u> Curve <u>3 of 7</u>
--	--	---

COMPACTION AND PENETRATION RESISTANCE REPORT

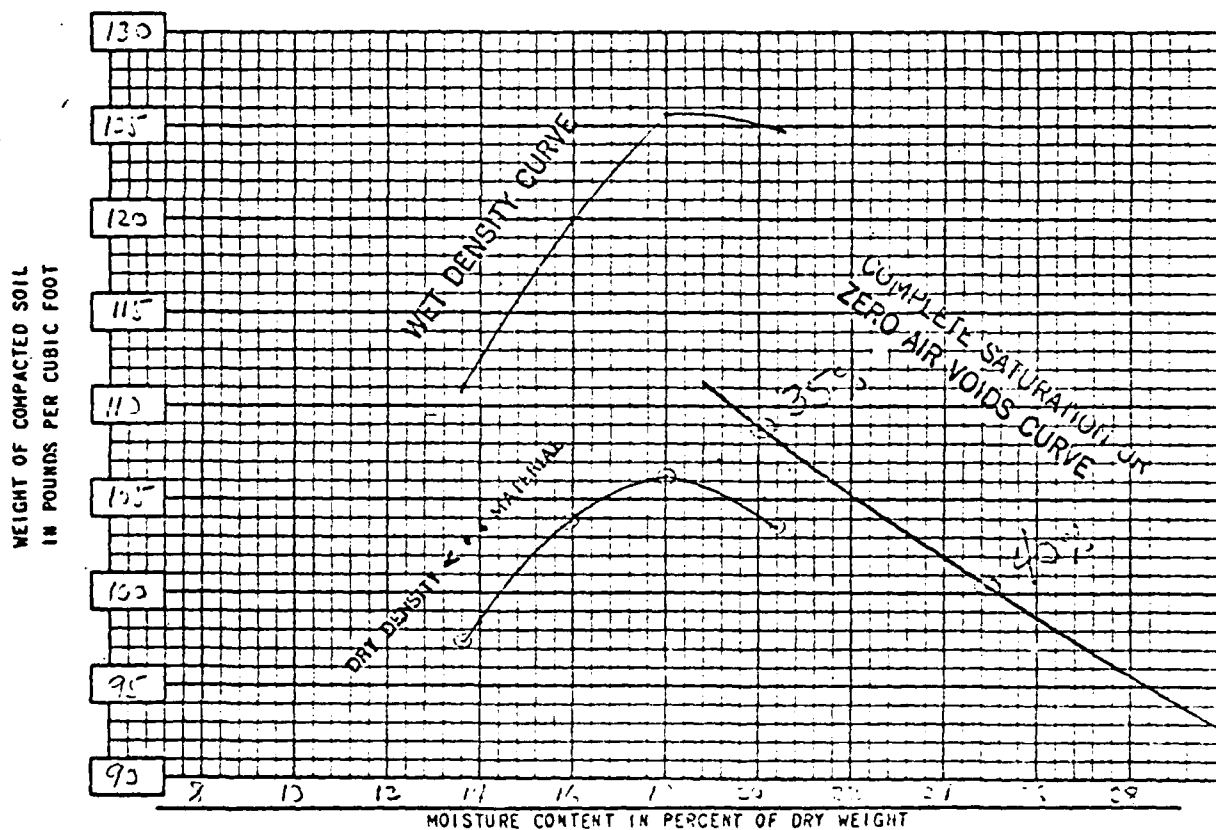
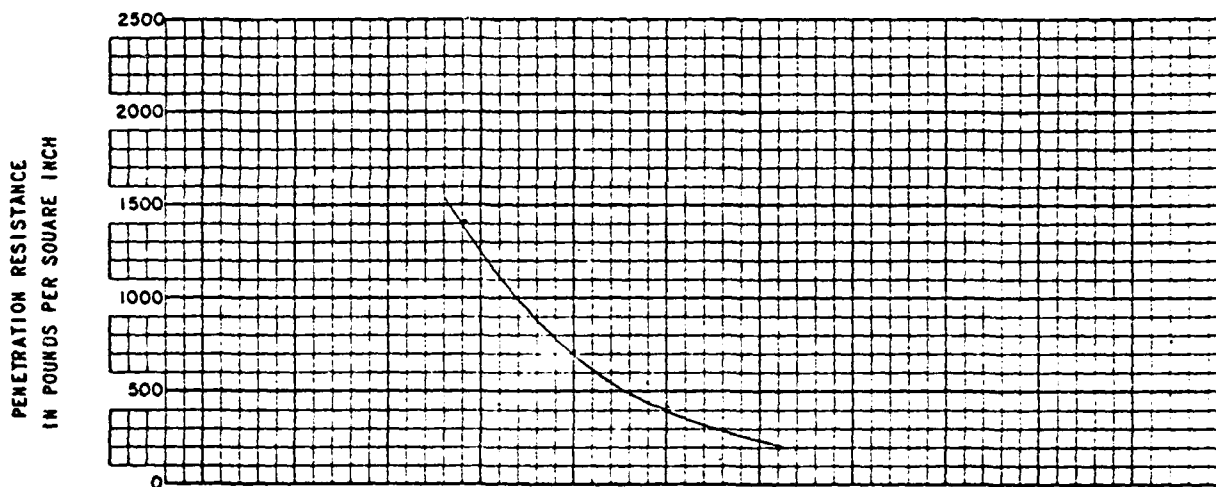
Date _____ Sample No.: Field 105-1 Lab 6303316
 Project 102 RIVER TRIBUTARIES "C-3" Location MISSOURI
 Sample Location and Depth Barrow 5+00 6+00 Depth 0-4'



TYPE OF TEST <input checked="" type="checkbox"/> Standard Proctor <input type="checkbox"/> Modified AASHO <input type="checkbox"/> Other _____	TEST PROCEDURE Weight of Hammer <u>5.5</u> Lbs. Drop <u>12</u> Inches Lifts <u>3</u> Vol. of Cylinder <u>1/30</u> Cu.Ft.	Classification <u>CL</u> Material compacted represents <u>100</u> percent of the sample and passed <u>"#1"</u> sieve (Sp. Gr.) $G_s =$ <u>2.68</u> Curve <u>4 of 7</u>
--	---	--

COMPACTION AND PENETRATION RESISTANCE REPORT

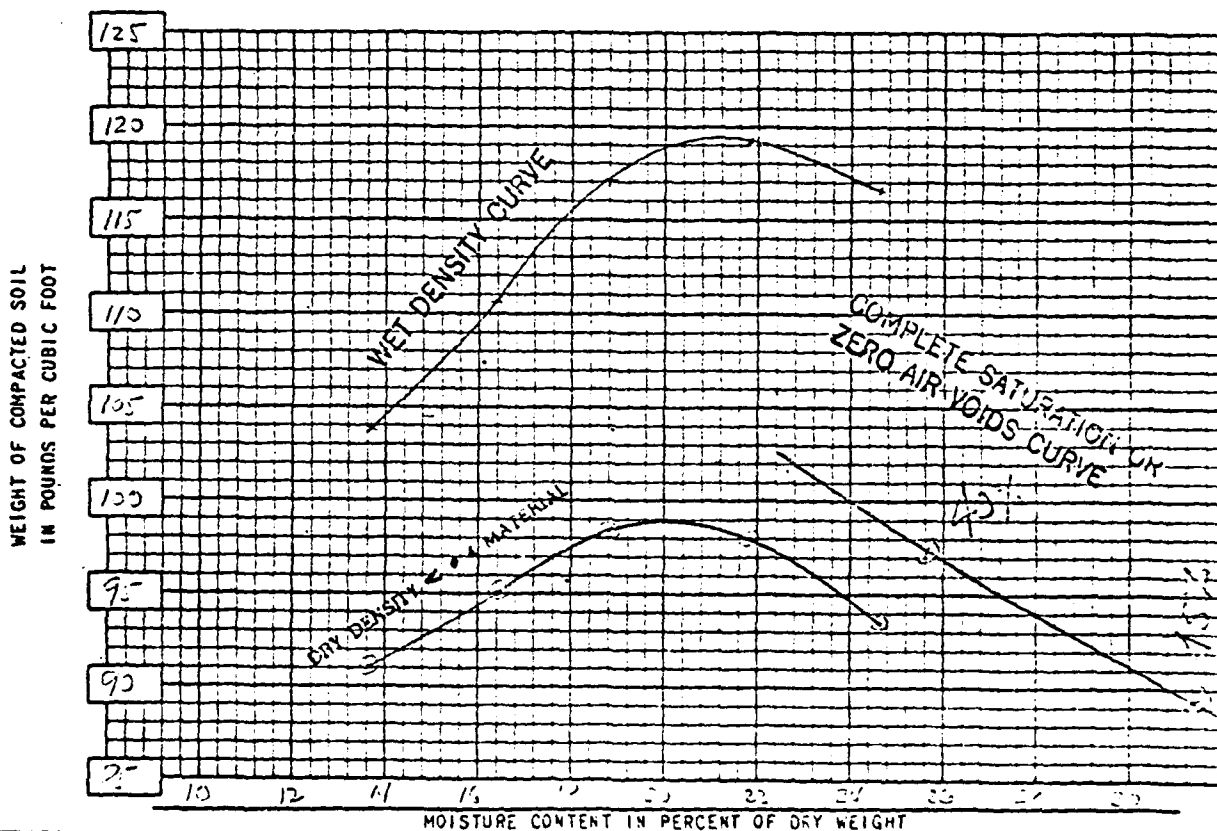
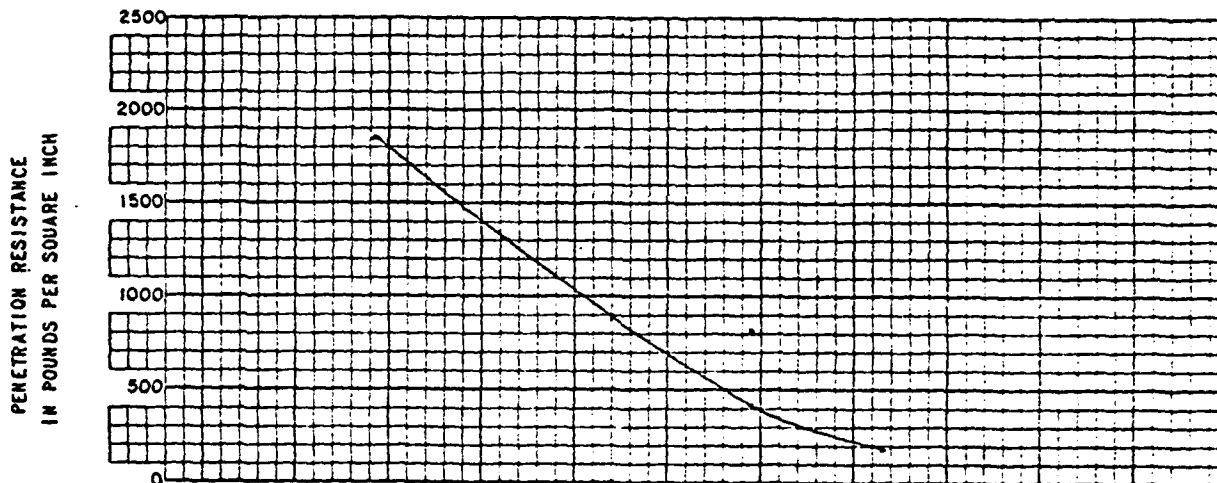
Date _____ Sample No.: Field 105-2 Lab 63003617
 Project 102 RIVER TRIBUTARIES #C-3 Location MISSOURI
 Sample Location and Depth BORING G-00 6-00 DEPT 4-12'



TYPE OF TEST	TEST PROCEDURE	Classification
<input checked="" type="checkbox"/> Standard Proctor	Weight of Hammer <u>5.5</u> Lbs.	Material compacted represents <u>100</u> percent of the sample and passed <u>"4"</u> sieve
<input type="checkbox"/> Modified AASHO	Drop <u>12</u> Inches	(Sp. Gr.) $G_s =$ <u>2.68</u>
<input type="checkbox"/> Other _____	Lifts <u>3</u>	Curve <u>5 of 7</u>
	Vol. of Cylinder <u>1/30</u> Cu.Ft.	

COMPACTION AND PENETRATION RESISTANCE REPORT

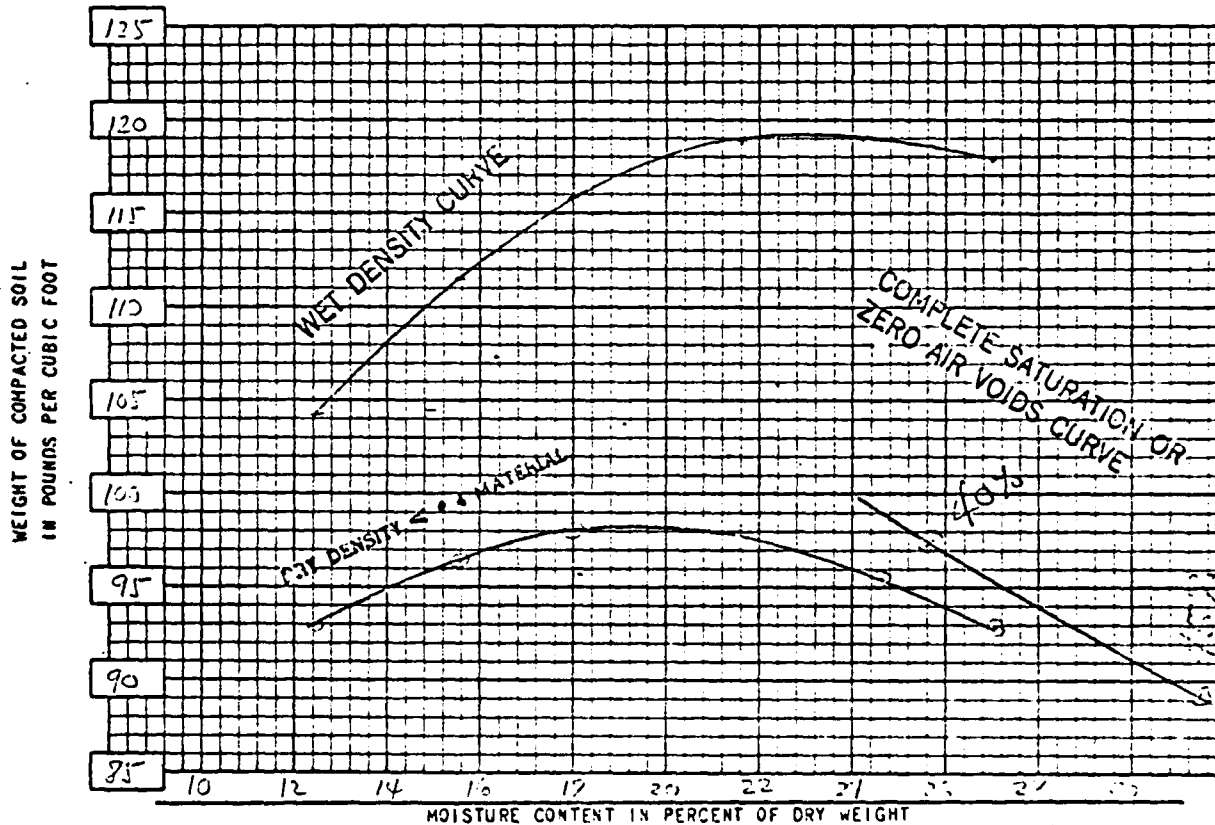
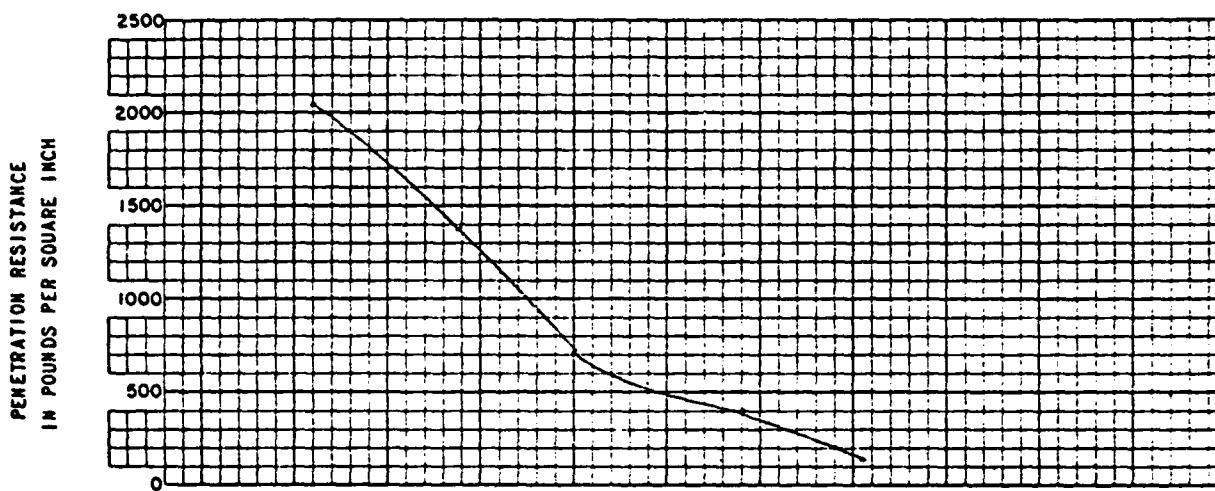
Date _____ Sample No.: Field 106-1 Lab 63113618
 Project 102 DIVER TRENCHING "C-2" Location MISSOURI
 Sample Location and Depth ROADWAY H+00 2+00 DEPTH 0-2'



TYPE OF TEST	TEST PROCEDURE	Classification
<input checked="" type="checkbox"/> Standard Proctor	Weight of Hammer <u>5.5</u> Lbs.	CL
<input type="checkbox"/> Modified AASHO	Drop <u>12</u> Inches	Material compacted represents <u>100</u> percent of the sample and passed <u>4/1</u> sieve
<input type="checkbox"/> Other _____	Lifts <u>3</u>	(Sp. Gr.) $G_s =$ <u>2.59</u>
	Vol. of Cylinder <u>1/30</u> Cu.Ft.	Curve <u>6 of 7</u>

COMPACTION AND PENETRATION RESISTANCE REPORT

Date _____ Sample No.: Field 106-2 Lab 63003619
 Project 102 RIVER TRIBUTARIES - C-3 Location MISSOURI
 Sample Location and Depth BORROW H+00 9+00 DEPTH 3-2'



TYPE OF TEST	TEST PROCEDURE	Classification <u>CL</u>
<input checked="" type="checkbox"/> Standard Proctor	Weight of Hammer <u>5.5</u> Lbs.	Material compacted represents <u>100</u> percent of the sample and passed <u>"4"</u> sieve
<input type="checkbox"/> Modified AASHO	Drop <u>12</u> Inches	(Sp. Gr.) $G_s =$ <u>2.62</u>
<input type="checkbox"/> Other _____	Lifts <u>3</u>	Curve <u>7 of 7</u>
	Vol. of Cylinder <u>1/30</u> Cu.Ft.	

SOIL MECHANICS LABORATORY
SUMMARY - SLOPE STABILITY ANALYSIS

State MISSOURI Project 102 RIVER TRIBUTARIES #C-3

Date 6-7-63 Analysis Made By G.L.M. Checked By G.N.G.

Method of Analysis Swedish Circle

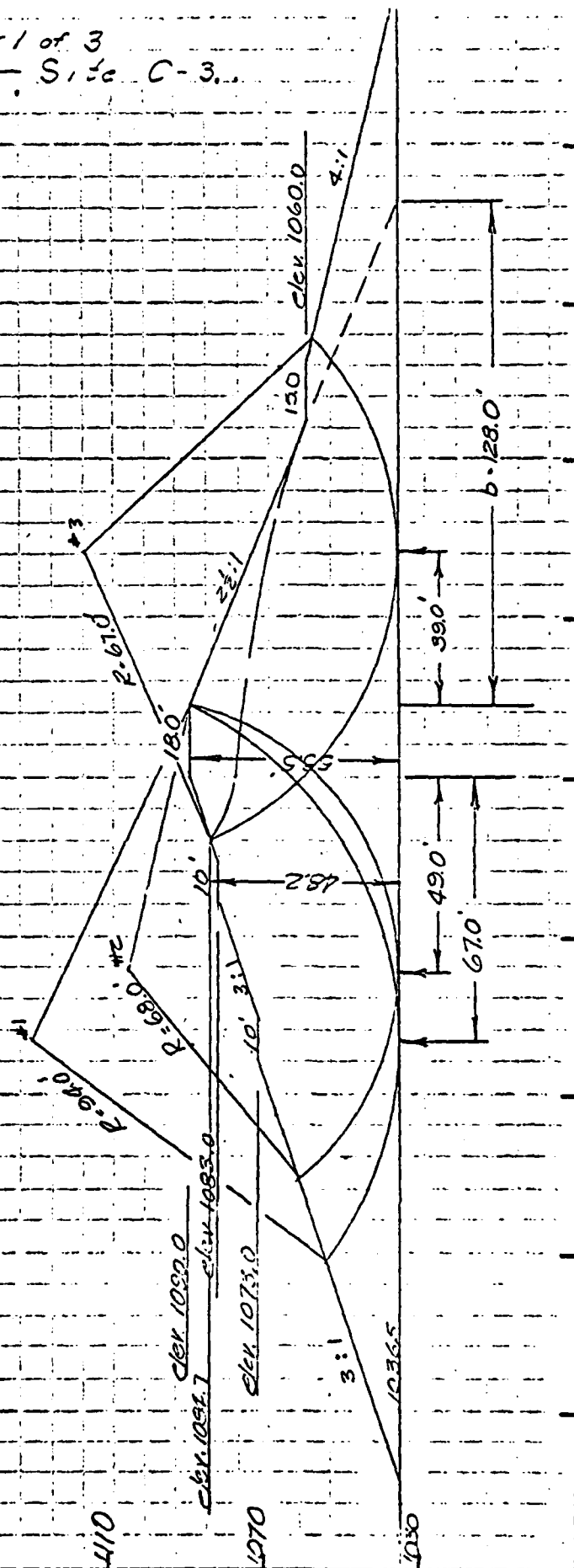
Location of Material	Found	Found	Found	Emd	
	CL	CH	CL	95% Std.	
Sample No.	62W13501	63W2R78	63W1359A	63W13613	
γ_d	95.2	96.4	88.8	102.7	
γ_m				117.5	
γ_s	121.5	122.5	117.5	125.5	
γ_b	59.0	60.0	55.0	63.0	
Condition	Opt. Sat.	Opt. Sat.	Opt. Sat.	Opt. Sat.	Opt. Sat.
ϕ		16.5°	21.0°	16.0°	8.5°
$\tan \phi$		0.296	0.394	0.287	0.149
k					
c		175	600	800	650

UPSTREAM SLOPE			
Trial	Slope	Conditions	Fs
1	3:1	Full drawdown - 102 term 2 elev 1093.0 - 100 term 2 elev 1073.0. Arc cut from 250' shoulder thru Emh 63W13613 only Sat. shear values only	1.49
2	3:1	Same as #1 but Tangent Point moved down 12.0'	1.70

DOWNSTREAM SLOPE			
Trial	Slope	Conditions	Fs
3	4:1	1/2 draw - 150' term 2 elev 1060.0. Arc cut from 250' shoulder thru Emh 63W13613 only Sat shear values only	1.40

To be used to report to field offices data used for slope stability analyses and the results of the analyses. The right side of the form will be used for a sketch of the embankment on which the analyses have been made.

MAXIMUM SECTION
STATION @ 9+50



Scale 1 inch = 40 Feet

SOIL MECHANICS LABORATORY
SUMMARY. - SLOPE STABILITY ANALYSIS

State MISSOURI Project 102 RIVER TRIBUTARIES #C-3

Date 6-10-63 Analysis Made By GLM Checked By GN.G.

Method of Analysis SWEDISH CIRCLE

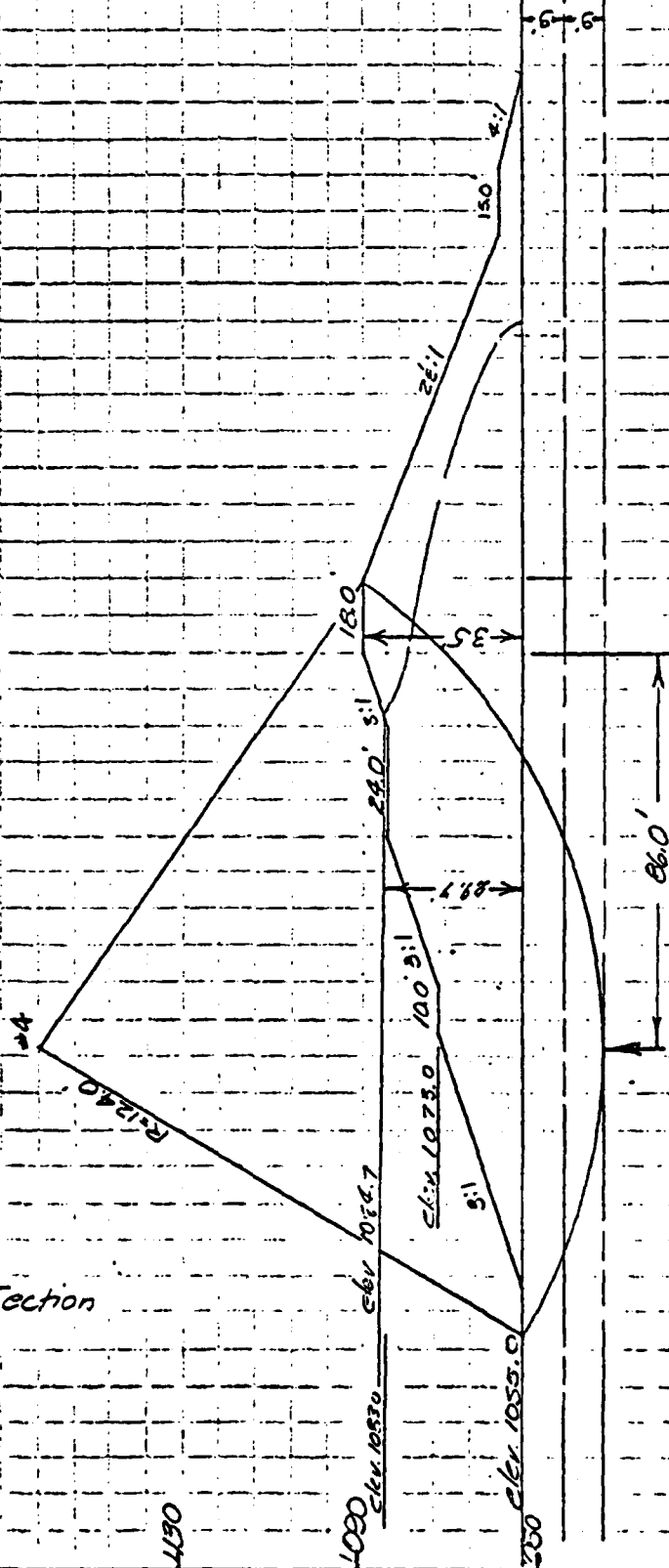
To be used to report to field offices data used for slope stability analyses and the results of the analyses. The right side of the form will be used for a sketch of the embankment on which the analyses have been made.

[illegible]

UPSTREAM SLOPE			
Trial	Slope	Conditions	Fs
4	3:1	Full drawdown - 10.0 berm @ elev. 1073.0 \$ 240' berm @ elev. 1053.0. Arc cut from opp. shldr thru Emd. 63W3613 & 180° Zoned Found. Sat. shear values only.	1.38
		Note: Zoning 0' - 9' of 63W3524 9' - 18' of 63W3524	

[illegible]

Principle Spillway Section
Station @ 6+90



Scale 1 inch = 40 Feet

SUMMARY - SLOPE STABILITY ANALYSIS

State MISSOURI

Project 102 RIVER TRIBUTARIES "C-3"

Date _____ Analysis Made By GLIMATCH & SONS Checked By G.M.S. & SONS

Method of Analysis SWEDISH CIRCLE

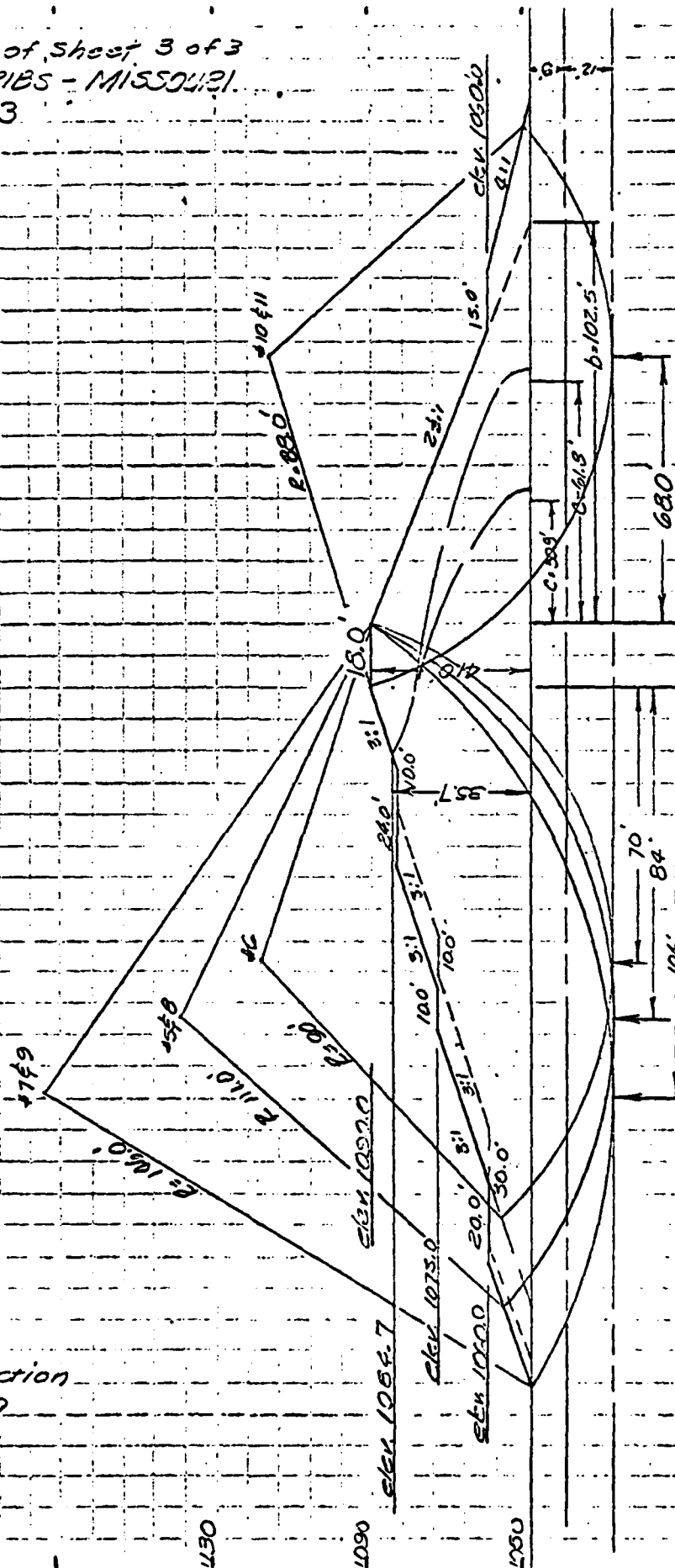
To be used to report to field offices data used for slope stability analyses and the results of the analyses.
The right side of the form will be used for a sketch of the embankment on which the analyses have been made.

Location of Material											
Sample No.	See sheet 1 of 3 for MAT'S										
γ_d											
γ_m											
γ_s											
γ_b											
Condition	Opt.	Sat.	Opt.	Sat.	Opt.	Sat.	Opt.	Sat.	Opt.	Sat.	
ϕ											
$\tan \phi$											
K											
C											

UPSTREAM SLOPE			
Trial	Slope	Conditions	Fs
5	3:1	Full ground - 250' berm @ elev 1053.0 & 100' berm @ elev 1073.0. Arc cut from ground line thru Elev 624.243 & 210° Found	
		Found. Soil shear values only	1.25
5A	3:1	Same as 5 but 200' berm @ elev 1060.0	1.45
6	3:1	Same as 5 but Tangent Point moved downstream 100'	1.35
7	3:1	Same as 5A but Tangent Point moved upstream 200'	1.32
8	3:1	Same as 5 but 100' berm @ elev 1053.0 & elev 1073.0	1.12
8A	3:1	Same as 5B but 300' berm @ elev 1060.0	1.35
9	3:1	Same as 5B but Tangent Point moved upstream 200'	1.34

DOWNSTREAM SLOPE			
Trial	Slope	Conditions	Fs
10	2.5:1	Drain @ Elev 0.3 - 150' berm @ elev 1060.0. Arc cut from ground line thru Elev 624.243 & 210° Found. Found.	
		Soil shear values only	1.43
11	2.5:1	Same as 10 but drain @ elev 0.6	1.22
		* Found Failing = 0'-9' - 210° - 600	
		9'-21' - 16.5° - 175	

Continuation of Sheet 3 of 3
102 RIVER TRIBS - MISSOURI.
Site C-3



Flood Plain Section
Station @ 8+50

Scale 1 inch = 40' Feet

APPENDIX D
HYDROLOGIC COMPUTATIONS

HYDROLOGIC COMPUTATIONS

1. The Mockes dimensionless standard curvilinear unit hydrograph and the SCS TR-20 program were used to develop the inflow hydrographs (see Plate D1). The inflow hydrograph for the 100-year flood is taken from design computations furnished by the SCS on their plans. However, a 100-year storm inflow was generated by the consultant using the TR-20 program and it compared closely in regards to peak and shape.

a. Six-hour, 100-year rainfall for the dam location was taken from NOAA Technical Paper 40, which compared closely with the furnished SCS value. The 24-hour probable maximum precipitation was taken from the curves of Hydrometeorological Report No. 33 and current OCE directives furnished 3 August 1978.

b. Drainage area = 1.14 square miles.

c. Time of concentration of runoff = 25 minutes.

d. The antecedent storm conditions were heavy rainfall and low temperatures which occurred on the previous 5 days (SCS AMCIII). The initial pool elevation was assumed at the crest of the principal spillway.

e. The total six-hour storm duration losses for the 100-year storm were 0.92 inches (SCS) which is a 0.23 PMF storm. The total losses for the 24-hour duration 1/2 PMF storm were 1.2 inches. The total losses for the PMF storm were 1.3 inches. These data are based on SCS runoff curve No. 90 and antecedent moisture conditions from SCS AMCIII.

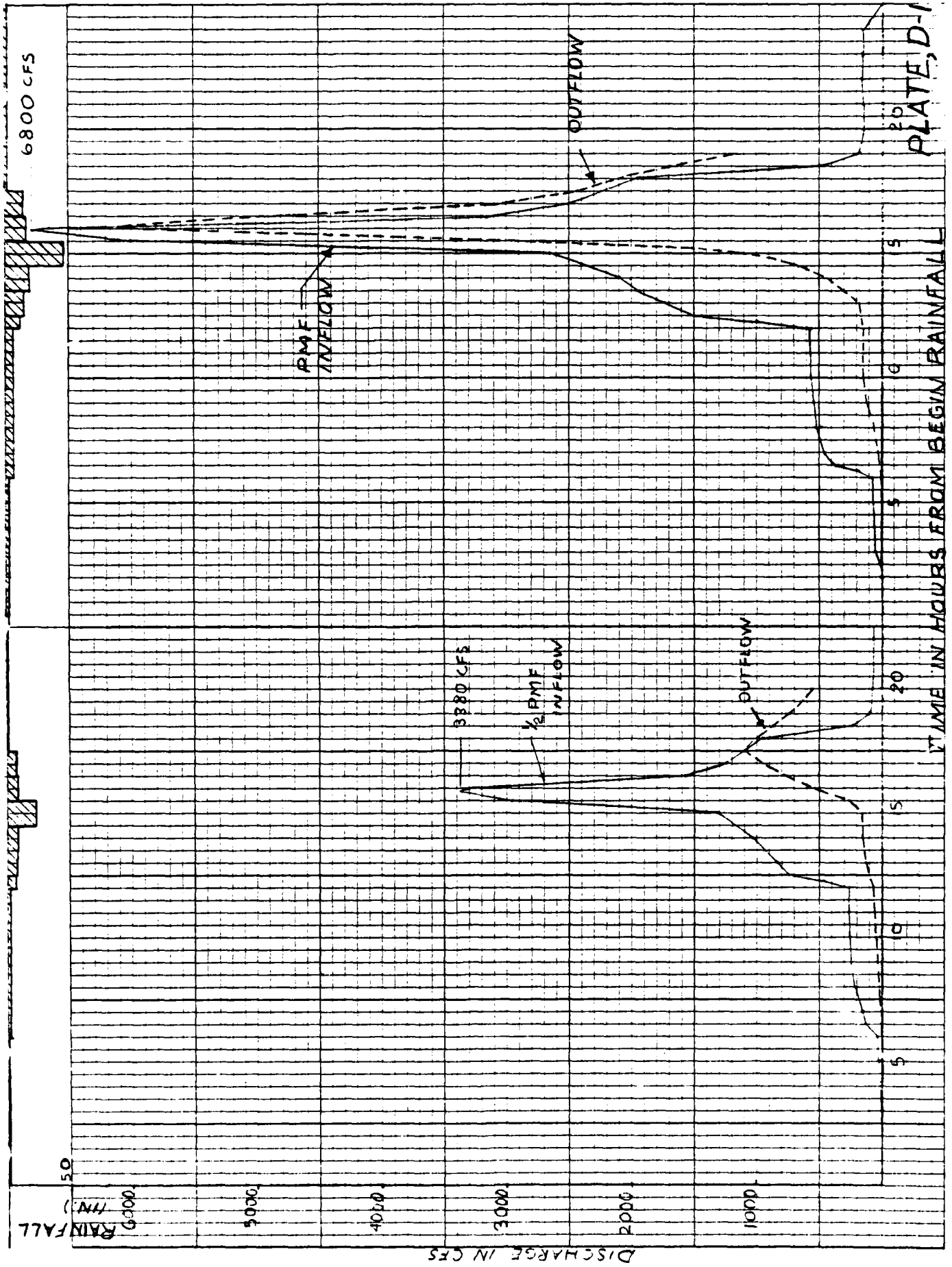
f. Average soil loss rates = 0.05 inch per hour approximately.

2. Combined spillway discharge ratings used were SCS design computations (sheet 1 of 4 E-20552-H) for the principal spillway. The emergency spillway rating was developed by extending the SCS design computations. This was done using the concept of critical depth in the spillway control section and conservative head losses through the spillway entrance section (head loss = $0.25 H_v$), where H_v is the velocity head at the spillway control section. These computations were compared using the SCS design computer program for rating and routing earth channel emergency spillways. The results compared reasonably. The flows over the dam crest are based on the broad crested weir equation ($Q = CLH^{3/2}$), where H is the head on the dam crest; the coefficient C , which varies with head, is taken from the USGS publication "Measurement of Peak Discharge at Dams by Indirect Methods: Book 3, Chapter 5, TWRI".

3. Floods were routed through the spillway using the TR-20 program to determine capability of the spillway and dam embankment crest. The storm rainfall patterns, inflow hydrographs and routed outflow hydrographs are given on Plate D1.

K•E 10 X 10 TO THE INCH • 7 X 10 INCHES
KEUFFEL & ESSER CO. MADE IN U.S.A.

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PLATE, D-1

STRUCTURE C-3

TIME CONVERSION FACTOR

1. 1.000000	2. 1.000000	3. 1.000000	4. 1.000000	5. 1.000000	6. 1.000000	7. 1.000000	8. 1.000000	9. 1.000000	10. 1.000000
-------------	-------------	-------------	-------------	-------------	-------------	-------------	-------------	-------------	--------------

CHECK OF FLOOD ROUTING

Time	Flow	Storage	Outflow	Time	Flow	Storage	Outflow
0	0	0	0	10	100	100	100
1	100	100	100	20	200	200	200
2	200	200	200	30	300	300	300
3	300	300	300	40	400	400	400
4	400	400	400	50	500	500	500
5	500	500	500	60	600	600	600
6	600	600	600	70	700	700	700
7	700	700	700	80	800	800	800
8	800	800	800	90	900	900	900
9	900	900	900	100	1000	1000	1000
10	1000	1000	1000	110	1100	1100	1100
11	1100	1100	1100	120	1200	1200	1200
12	1200	1200	1200	130	1300	1300	1300
13	1300	1300	1300	140	1400	1400	1400
14	1400	1400	1400	150	1500	1500	1500
15	1500	1500	1500	160	1600	1600	1600
16	1600	1600	1600	170	1700	1700	1700
17	1700	1700	1700	180	1800	1800	1800
18	1800	1800	1800	190	1900	1900	1900
19	1900	1900	1900	200	2000	2000	2000
20	2000	2000	2000	210	2100	2100	2100
21	2100	2100	2100	220	2200	2200	2200
22	2200	2200	2200	230	2300	2300	2300
23	2300	2300	2300	240	2400	2400	2400
24	2400	2400	2400	250	2500	2500	2500
25	2500	2500	2500	260	2600	2600	2600
26	2600	2600	2600	270	2700	2700	2700
27	2700	2700	2700	280	2800	2800	2800
28	2800	2800	2800	290	2900	2900	2900
29	2900	2900	2900	300	3000	3000	3000
30	3000	3000	3000	310	3100	3100	3100
31	3100	3100	3100	320	3200	3200	3200
32	3200	3200	3200	330	3300	3300	3300
33	3300	3300	3300	340	3400	3400	3400
34	3400	3400	3400	350	3500	3500	3500
35	3500	3500	3500	360	3600	3600	3600
36	3600	3600	3600	370	3700	3700	3700
37	3700	3700	3700	380	3800	3800	3800
38	3800	3800	3800	390	3900	3900	3900
39	3900	3900	3900	400	4000	4000	4000
40	4000	4000	4000	410	4100	4100	4100
41	4100	4100	4100	420	4200	4200	4200
42	4200	4200	4200	430	4300	4300	4300
43	4300	4300	4300	440	4400	4400	4400
44	4400	4400	4400	450	4500	4500	4500
45	4500	4500	4500	460	4600	4600	